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THE UNIVERSITY OF ALBERTA

GSR, HR RESPONSES, AND VIGILANCE BEHAVIOR
IN NORMAL AND RETARDED CHILDREN

by

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ABSTRACT

The present study examined the galvanic skin and heart rate responses of 15 normal and 30 educable mentally retarded children, during a 30-minute vigilance task in an attempt to delineate a presumed "attentional" deficit in the retarded.

The task consisted of pressing a key whenever the signal sequence MAN BOY MAN was heard. The background nonsignals consisted of the sequences MAN BOY CHAIR, MAN KEY MAN, and CAT BOY MAN. The mentally retarded children were randomly assigned to one of the two conditions, instructed and noninstructed (15 *Ss* in each condition). The instructed group was told to rehearse overtly throughout the session the sequence: "MAN BOY MAN Press!" The noninstructed group was only given the instructions to press the key whenever they heard the signal sequence MAN BOY MAN, which were the identical instructions for the normals.

The noninstructed committed a greater number of false detection and omission errors in vigilance than the normals. The number of omission errors differentiated the instructed group from the noninstructed, the latter group committing more errors. The heart rate and GSR also differentiated the groups, although this was not consistently evident.

The results were interpreted in terms of a possible deficit in the mentally retarded with respect to the selective component of "attention" as indicated in the orienting responses to some of the nonsignals. However, the retardates could not be distinguished from the normals on the alerting or *general* arousal components. Specific instructions to rehearse in this particular task were effective in raising the level of

vigilance performance of the mentally retarded. It is suggested that this is an aspect requiring further study which would utilize different tasks and strategies.

Sylvia

It would not be appropriate if one did not recognize one of the most important participants in the completion of the following study. My loving wife, who displayed a degree of patience which should be required of no one, was a great source of inspiration and understanding. Her comments, "Just get it finished", were a great help in "getting it finished". If not for her enduring disposition and support, as well as that of my two sons, Cory and Darren, this modest piece of work could not have been completed. To them my deepest appreciation.

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CHAPTER I

INTRODUCTION

Professionals working with retarded children have noted a wide variety of behavioral differences. Probably most often noted is that of "attention". When the retarded child fails to learn a task as rapidly as the normal, then attentional deficit is often hypothesized to account for this difference in learning rate (Zeaman & House, 1963; Ellis, 1963).

There are a variety of procedures used to study attention in humans, including dichotic listening, vigilance and the orienting response (Worden, 1966; Swetz & Kristofferson, 1970). Of these, the presently proposed study uses the orienting response <u>and</u> a vigilance task as a method to examine the attention of the retardate to verbal stimuli. Focusing on verbal stimuli, one may combine two major types of attention: The attention to external events and attention to internal events such as memory and thought (Lacey, 1959).

Habituation of the orienting response has been the subject of several investigations as reviewed by Karrer (1966). Habituation is defined as a response decrement to a repeated stimulus (Thompson & Spencer, 1966). Thus, as a stimulus is repeatedly presented, it fails to evoke an orienting response. Habituation has been found to be faster in the retardate in some but not all studies (Karrer, 1966). The lack of agreement seems to be due to variations in tasks, subjects and the experimental conditions. Few studies have used verbal stimuli and the literature is almost void with respect to vigilance performance,

and simultaneous orienting response habituation measures with normal-retardate comparisons.

Vigilance tasks require a reasonably high degree of attentiveness from the subject, allowing him to detect changes in stimuli events and select the signal stimuli from the background nonsignal stimuli. The tasks are usually conducted in an environment where all irrelevant stimuli are controlled. Vigilance studies should therefore delineate further the "attentional" behavior of mentally retarded subjects, particularly when an additional index of "attention" such as the orienting response is employed.

There is a considerable amount of evidence that training mental retardates in the use of strategies in which to cope with short-term memory tasks is effective in raising their levels of performance on the tasks (cf. Belmont, Wambold & Butterfield, 1973). Would this be the case in a vigilance task enabling the retardate to be more "selective" in his attending?

This study was concerned with vigilance behavior and concomitant autonomic responses (OR) of heart rate and galvanic skin responses of normals and mental retardates. The effect of training the retardate in a rehearsal strategy in which to cope with the vigilance task was also of major concern in the study.

CHAPTER II

SELECTIVE REVIEW OF RELATED LITERATURE

Attention and Mental Retardation

Psychology has been concerned with the process of "attention" for a great many years. It is difficult to define "attention" without some difficulty. In general terms, it can be considered as a "mental faculty" that selects one or a number of external or internal stimuli (Mackworth, 1970). According to Neisser (1967), "attention" is directional and is an active, reconstructive, general cognitive function. The historical antecedents surrounding the concepts of attention have been well documented (Mastofsky, 1970; Trabasso & Bower, 1967). The following discussion will focus, therefore, on some current aspects of attention as they relate to the present study and, in particular, the mentally retarded child.

Some writers have discussed different components which make up the general construct of "attention". Posner and Bois (1971) discussed "attention" in terms of three basic components: _alertness_, _selectivity_ and _processing capacity_. Pribram and McGuinness (1975) described "attention" in much the same terms as Posner _et al_. (1971). Pribram _et al_. (1975) have considered "attention" in terms of three basic control systems. One controls _arousal_, which they define in terms of phasic physiological responses to input. A second system controls _activation_ and is defined in terms of tonic physiological readiness to respond. The third system co-ordinates activation and arousal, and is

defined as requiring effort. The three systems, arousal, activation and effort, control "attention".

In mental retardation, "attention" has been a key construct. A number of researchers have noted that the retardate appears to suffer from an attentional deficit and therefore they suggest that this is what affects the retardate's ability to learn (Luria, 1963; O'Connor & Hermelin, 1963; Ellis, 1963; Zeaman & House, 1963). The reason for this deficit is most often attributed to a weak central nervous system. This hypothesis of a pathological condition of the cortex appears to be strongly favored by Soviet investigators (Sokolov, 1963; Luria, 1963).

When one considers the above components or systems and the complexity of their interactions in the "attending" process, the question arises as to whether the retardate's presumed "attention" deficit is related to any one component in particular or whether it is a function of the total process of "attention". The literature does not offer a clear-cut answer to this.

Arousal

A number of studies point to impaired alerting or arousal in the mentally retarded. Clausen (1973) defines "arousal" as ". . . the general response or response readiness of an individual, modifiable by stimulation and measurable in terms of performance level or psycho-physiological activity (p. 286)."

Clausen (1966) concluded from his analysis of ability structure that the retardate suffers from an impairment of mobilization of arousal and this would therefore adversely affect his performance.

Holden (1965), in studying the speed of response (RT), lends support to the inference of impaired mobilization of arousal. Baumeister and Kellas (1968), in their comprehensive review of reaction time (RT) studies dealing with the mental retardate, also suggest an arousal deficit: "Enough evidence has been presented to lead to the tentative conclusion that retardates suffer a prestimulus arousal deficiency or attentional lag (p. 188)." Meldman (1970) also suggests an arousal deficit in the retardate. He describes mental deficiency as mental hypoattentionism. The retardate further exhibits a low arousal and low selectivity of attention. Therefore, in tasks requiring selective attention Meldman's hypothesis would indicate that the mentally retarded would do poorly when compared to a normal person of the same chronological age (CA). The theory of hypoattentionism postulated by Meldman (1970) is very much in line with the views of Ellis (1963) and Luria (1963, 1971) in that CNS impairment is indicated.

It is true that the mentally retarded have consistently displayed slower response speed than CA or MA matched normals (Baumeister & Kellas, 1968). However, the question as to whether this is a function of arousal has still not been answered conclusively. Crosby (1972) found that brain-damaged, institutionalized retarded subjects and young children (9 years) of average intelligence displayed least adequate performance as compared to non-brain-damaged and older normal children on a task requiring them to respond to an X when they saw it occur. However, they performed well in a task in which they were required to press a button whenever they noted an X immediately following an A. Crosby (1972) suggests that the A, or warning signal, had an arousing

effect. This is generally suggested in RT tasks (Baumeister & Kellas, 1968). However, there were no objective measures of arousal, such as galvanic skin response or heart rate, taken in Crosby's study. To more objectively determine the arousal component with respect to performance in an attentional task, the physiological measures or galvanic skin response and heart rate would seem to be appropriate.

Retardates have been found to be less responsive in autonomic nervous system (ANS) measures such as the GSR (Karrer, 1966). The GSR has frequently been used as an objective measure of arousal, the inference being that the mental retardate suffers from an arousal deficit, and that this affects the RT performance as well as other tasks requiring sustained attention. However, when resting skin conductance levels (SCLs) are considered the evidence supporting arousal differences is not clear. In a review article, Karrer (1966) suggests that there is considerable support for the findings of higher SCLs for the mentally retarded population. Studies published subsequent to the Karrer (1966) review do not wholly support the findings that mentally retarded Ss display higher SCLs than normals (Stern & Jones, 1973). The results of these studies are somewhat contradictory. According to the Stern et al. (1973) review, three studies have found mentally retarded subjects more aroused than normals (higher SCLs) (O'Connor & Venables, 1956; Ellis & Sloan, 1958; Karrer & Clausen, 1964), two have found the mentally retarded less aroused than normals (lower SCLs) (Collman, 1959; Fenz & McCabe, 1971), two studies obtained no differences (Lobb, 1968; Clausen & Karrer, 1970), and one study obtained mixed results (Berkson, Hermelin & O'Connor, 1961). Attempts were made

in the majority of the above studies to eliminate brain-damaged Ss. The summary one reaches with respect to these findings is that they are inconsistent, but that there is a trend toward no difference in resting SCLs of normals and retardates. As mentioned above, the hypothesis of arousal deficit and mental retardation is still an open question. The majority of studies conducted which have suggested an arousal deficit have not used ANS measures of arousal in a task requiring sustained attention. The research also has concentrated on simple stimuli which have little meaning for the subject, utilizing such things as letters, tones, light flashes, etc. Rarely have meaningful, verbal stimuli been employed.

Selectivity

The most critical symptom of attentional deficit in the mental retardate is believed to be his proneness to distraction (Zeaman & House, 1963; Luria, 1963). This inadequate inhibition of response to task-irrelevant stimuli is postulated to be an important component of the behavioral inefficiency of the retardate in tasks requiring sustained attention. As in arousal deficit, there is a considerable amount of research evidence from discrimination learning studies that attending to relevant stimuli (selection) is impaired (Zeaman & House, 1963). Visual search studies (Spitz, 1969) suggest that the mental retardate is an inefficient scanner of visual information. The selectivity component of attention and its ability to focus on appropriate information depends a great deal on the ability to inhibit responses to irrelevant stimuli (distraction). Some studies have shown

that the retardate is no more distractible than MA or CA matched normals (Crosby, 1972), whereas others have shown greater distractibility of retardates (Wolitzky, Hofer & Shapiro, 1972). Therefore, there is some question regarding a deficit in the retarded in terms of the selectivity component of attention. There is also evidence that the attention span or processing capacity component of attention is impaired in retardates. Stimulus processing time of necessity affects attentional capacity. It has been demonstrated that retardates process stimuli more slowly than normals (Holden, 1970; Thor, 1971) and thereby could be considered to have less attentional span capacity. This, in all likelihood, gives rise to the slower RT of retardates when compared to CA or MA matched normals. The longer the processing time, the longer would be the RT. This study was concerned first and foremost with the selectivity component of attention in the mentally retarded.

Some Theories of Attention Deficit

Zeaman and House theory

As mentioned above, Zeaman and House (1963) concluded from their studies of the discrimination learning of retardates that they suffer from an attentional deficit. Specifically, the retardate is presumed to suffer from an inability to attend to the relevant dimension and to zero in on the cues of the relevant dimension.

In a number of visual discrimination learning tasks the performance of groups of retarded subjects was compared to nonretarded groups. When one examines the slopes of the bakcward learning curves of the retarded subjects, the final portions of the curves are not distinguishable

from the normal subjects. Thus, Zeaman and House conclude that "learning rate is not a particularly important source of variance in discrimination learning of the retardates (p. 217)." They suggest, therefore, that because the retardates required significantly more trials forlearning to begin, the deficit must lie in attention.

In a more recent paper (Fisher & Zeaman, 1973) the original position of attentional deficit has been revised. Zeaman now believes that memory or the immediate retentional abilities of the retardate are at fault, not their attentional ability *per se*. He suggests that the retardate has a faster short-term memory decay rate and a limited capacity for rehearsal. Zeaman now suggests that the deficit in retardate learning rate lies "in the domain of memory rather than learning, extinction, or attention (p. 251)".

Stimulus trace theory: Ellis

Ellis (1963) derived his stimulus trace theory of mental retardation from the work of Hull (1952), who hypothesized that when a cue and a stimulus are tenuously connected, a stimulus trace is left on the cortex, and the trace fades away over time. Ellis found retardates to be defective in short-term memory and immediate recall. He suggested that the retardate is defective in stimulus trace, i.e., there is an inadequate trace being left on the cortex, or as Ellis puts it, "loose CNS integration".

Ellis (1963), as did Zeaman, has since revised his original hypothesis of stimulus trace deficit. Ellis (1970), through a series of studies involving short-term memory, puts forth the argument that

the mentally retarded are deficient in short-term memory and more specifically they lack "rehearsal mechanisms" which he claims are necessary for one of the storage processes in memory. This process assists the transferring of information from primary memory to secondary memory to tertiary memory. The evidence cited in support of the hypothesis is quite impressive. The primacy-recency effect found in memory experiments was the basis for the studies. The primacy component, he claims, is related to short-term memory and the main component of recency is primary memory. The studies cited indicated a lesser primacy effect for the retarded (first items lost from memory to a greater extent than normals). Particular evidence was indicated for rehearsal deficit in the findings that spacing of items in a message facilitated normals' performance and not that of CA matched retardates and normals also indicated that a delay interval after stimulus presentation facilitated primacy performance, if the rate of presentation had been rapid. Also, verbal reports of normal subjects suggested that they were rehearsing, whereas retardates reported minimal rehearsal activity. The rehearsal deficit postulated by Ellis (1970) has obtained support and elaboration, particularly by Belmont and Butterfield (see for example, Butterfield, Wombold & Belmont, 1973). There is also the finding that a deficit by retarded Ss in paired-associate learning can be eliminated simply by verbal instruction to rehearse (Gordon & Baumeister, 1972).

Attention and the Orienting Response

The orienting response is one of the basic measures of attention, as it is related to the arousal and selectivity components of attention. The orienting response, or as Pavlov (1924) called it, the "What is it?" reflex, is a response to encounters with informative stimuli. It is comprised of a number of components, including such responses as increased sensitivity of sense organs, changes in skeletal muscles that direct sense organs, EEG and vegetative changes (Lynn, 1966, pp. 2-4). The increase in sensitivity includes such things as pupil dilation and lowering of auditory threshold. Changes in skeletal muscles include overt bodily movements, such as head movement toward the source of stimulation. Vegetative changes include vasoconstriction in the limbs and vasodilation in the head, as well as delay in respiration rate followed by increase in amplitude and decrease in frequency. The galvanic skin response (GSR) increases. Heart rate, according to most Western researchers, decreases (deceleration). Considerable controversy surrounds the heart rate (HR) component of the OR which will be discussed in some detail in a later section of this paper.

This functionally related system of reactions is believed to result from detection of a violation of expected stimulus input, and appears to prepare the organism for better reception of stimuli. It may occur as an unconditioned response or as a conditioned response to signal stimuli, such as a person's name (Stern, 1972). The most comprehensive model for the orienting response has been advanced by Sokolov (1963, 1969). According to his now familiar theory, the

analysis of incoming stimuli takes place in the cortex and upon analysis the cortex either excites or inhibits the reticular formation. If the incoming stimulus matches an existing "neuronal model" then the cortex inhibits the reticular formation and the orienting response is blocked. It occurs only if there is a mismatch or discrepancy between the existing neuronal model and the incoming stimulus. It would then appear that when information is gained which requires analysis, there is an orienting response (Sokolov, 1969, p. 702).

Habituation of the Orienting Response

Habituation has been defined as response decrement to a repeated stimulus (Harris, 1943; Thompson & Spencer, 1966). It would appear that in many instances the terms habituation, adaptation, accommodation, inhibition and extinction are used by different investigators to account for the same general phenomenon. Psychologists have shown particular interest in this phenomenon because of its importance in inattentive behavior (Mackworth, 1969). A complete review of habituation will not be given here as Mackworth (1969) provides an excellent one, using vigilance task experiments in order to investigate habituation of a repetitive event.

Thompson and Spencer (1966) presented a relatively specific account of the general laws that apply to habituation of the orienting response. A summary of these general laws is as follows:

1. Decrease in response was usually a negative exponential function of the number of stimulus presentations (faster rate of presentation produces a faster habituation rate).

2. The response recovers when the stimulus is omitted.
3. Habituation is faster for weak stimuli, provided discrimination is not required.
4. Habituation of one kind of stimuli may generalize to another of similar kind.
5. The rate of habituation depends on the regularity of the stimulus.
6. When the stimulus requires a response or a decision as to whether or not to respond, habituation is delayed (Sokolov, 1963). In such situations habituation may be slower when the discrimination is made.

Habituation, in terms of Sokolov's theory, is associated with the development of a "model" of the "stimulus" somewhere within the cortex. The model is changed and refined upon repeated application of the stimuli. When the "neuronal model" matches the incoming stimuli, the cortex inhibits the reticular formation and the orienting response is blocked. In view of Sokolov's theory, if one is repeatedly exposed to a stimulus, the neuronal model becomes more clearly differentiated with regard to all aspects of the stimuli (temporal, spatial and intensity). Habituation then occurs more rapidly with a familiar stimulus than with an unfamiliar stimulus and/or one which has little meaning as a result of possible lack of exposure. Thus, experience with the stimuli should be a crucial factor in the rate and amount of habituation one observes.

Much of the research aimed at delineating the characteristics of habituation of the orienting response have not controlled for differences between an orienting response and a defense or startle response (Davis,

Buchwald & Frankman, 1955; Lang & Hnatiow, 1962; Groves & Thompson, 1970). In some cases stimulus intensities may have been strong enough to evoke a defensive reaction. Studies have shown that habituation of the orienting response differs markedly from habituation of a defensive reaction (Raskin, Kostes & Bevers, 1969), with the defensive reaction being much slower to habituate than the orienting response.

Horowitz (1970) assessed the habituation of cardiac responses of 6 month old male infants in the presence of both familiar and discrepant auditory stimuli. All of the infants displayed progressive habituation of the cardiac deceleration response in the presence of a repetitive stimulus consisting of two contiguous tones.

In a second-by-second analysis of heart rate, Myers (1970) found significant deceleration of heart rate to a moderate (70 dB) and loud (95 dB) tone in 11 to 13 year old children. The 70 dB tone upon repetition displayed significant habituation of the deceleration component of heart rate. The results were consistent with Sokolov (1960) in that a nonfamiliar stimulus will produce an orienting response and subsequent deceleration of heart rate. However, upon repetition the loud tones (95 dB) displayed a significant deceleration component which resisted habituation. As a result of this study, Myers (1970) suggests that Graham and Clifton's (1966) hypothesis that heart rate deceleration as a cardiac component of the orienting response should be restricted to unfamiliar stimuli.

The children's responses in Myers' (1970) study differed from the adult responses observed by Myers and Gullickson (1967). Both studies used the same procedure and stimuli. In their 1967 study the reversal

of the 70 dB tones produced reliable cardiac deceleration in the adults, but the children did not display this dishabituation on reversal. They conclude that the nature of the age differences is unclear. The children could conceivably have been less perceptive than the adults to the changes in tonal pattern. It is, however, somewhat fallacious to look at two different studies and draw conclusions about age differences when the environmental situations surrounding each may have been quite different. Even though each study was a replicate of the other in terms of stimuli and measures, the conditions within the studies could have been quite different (atmosphere, experimenter, situation, etc.).

Lewis, Campbell and Goldberg (1969), dealing with infants (ages of 3 months to 3 years), conclude that:

> (a) Response decrement is produced by a redundant visual signal during the first three years of life; and (b) the degree of this response decrement follows a developmental pattern, with younger infants showing less decrement than older infants (p. 30).

These results are based primarily on visual fixation data although one study incorporated heart rate measures. In this study there were no significant differences in heart rate deceleration as a result of repetition. The heart rate acceleration component also displayed no habituation for any of the five age groups (12 weeks, 24 weeks, 36 weeks, 56 weeks and 68 weeks).

Bower and Das (1972), in a study of the orienting response to words and nonsense syllables of normal and retarded children, found only minimal habituation of heart rate where Myers (1969) and Lewis, Campbell and Goldberg (1969) had found rapid habituation employing

nonverbal signals. In the former study, however, the children were much older than the subjects in the two latter studies.

From the above discussion, it is apparent that there are conflicting findings with respect to habituation of heart rate component of the orienting response. This contoversy will be discussed further in the section on "Components of the Orienting Response".

Habituation of the Orienting Response in the Mentally Retarded

Luria (1963) has outlined a definition of mental retardation representative of the Moscow Institute of Defectology. According to Soviet investigators, mental retardation is a result of damage to the central nervous system during the intrauterine period or during early childhood. All retardates (those with known etiology and those of unknown etiology) are believed to suffer from some neurophysiological defect. In an attempt to specify this "defect", Luria (1963) investigated the cognitive processes of retarded children as compared to "normals".

According to Luria (1961), speech begins to regulate simple motor acts by the age of 5 1/2 years. He noted that the behavior of the retarded child resembles that of a chronologically younger child in that verbal instructions do not assume a regulatory function with respect to motor behavior. This dissociation of speech and motor reactions or "dissociation of the two signaling systems" was interpreted by Luria as an indication of underdevelopment or general "inertia" of the verbal system. This has been described by Luria as the major defect in retarded children.

Luria (1963) has also suggested that the mentally retarded child cannot maintain an orienting response and that habituation of an orienting response is much faster in the mentally retarded than in the "normal": "The instability of active attention fundamental to the swift extinction of the orientation reflexes in the mentally retarded leads to the complex connections formed by him quickly extinguishing (Luria, 1963, p. 104)." Luria (1963) also suggests that the mentally retarded child is highly distractable and thus his attention span is impaired: ". . . the great proneness to distraction of the mentally retarded child appears as an inability to maintain his attention (p. 104)." Luria has also observed that the usual procedures to prevent orienting response habituation by instructions are not effective in the retardate. However, a number of studies with retarded children suggest that there is not a general defect in the orienting response (Das & Bower, 1971a; Das & Bower, 1971b; Bower & Das, 1972).

The work of Das and Bower agrees with the more recent writings of Luria (1971), who has maintained that habituation of the orienting response can be resisted if we instruct the subject to pay attention to the stimulus or direct his attention to a response. He describes this as regulation of vigilance for which the frontal lobes are specifically responsible. Thus, if there is no frontal lobe damage the retarded child would display comparable regulation of vigilance performance as the normal child when instructions to maintain attention or perform a motor response are given.

Luria's findings of a weak OR in retarded subjects has found inconsistent support from Western attempts to replicate his results

(Heal & Johnson, 1970). In particular, the faster rate of habituation of OR in the retarded child suggested by Luria has obtained virtually no support (Elliott & Johnson, 1971; Baumeister, Spain & Ellis, 1963; Tizard, 1968; Clausen & Karrer, 1968). Few studies have taken into account the role of instructional set hypothesized by Luria (1971), and there are none that this writer could find that related this to a task requiring prolonged attention as found in vigilance tasks.

In the present study it is planned to explore Luria's suggestion that one can produce a resistance to habituation of the orienting response of the retarded through the use of instructions, and to observe habituation of the orienting response with respect to decrement in a vigilance task and normal-retardate differences. One would suspect that in a reasonably complex vigilance task utilizing verbal stimuli retardates would do poorly without training in the use of verbal mediation (Luria, 1963) and/or rehearsal strategies (Fisher & Zeaman, 1973; Ellis, 1970).

Components of the Orienting Response

The unitary nature of the orienting response is of considerable theoretical and practical interest. Soviet researchers, such as Sokolov (1960, 1963), discuss the components of the orienting response rather than <u>the</u> orienting response. Stern (1972) agrees with this because of the lack of consistent and significant correlations between the different components of the orienting response. Often habituation of GSR does not correlate highly with habituation of HR. In fact, in some cases habituation of heart rate may be lacking

completely, whereas GSR will display a definite trend towards habituation (Mulcahy & Das, 1973). This phenomenon appears to be related to specific task conditions and interaction of these conditions with the response systems. This has been described as "situational sterotype" by Lacey (1967). It would seem advisable, then, in any experiment to look at more than one component of the OR. As a result, the evidence thus obtained from different response systems under different conditions might complement each other.

Heart Rate and Galvanic Skin Response

Heart rate and galvanic skin response have both been accepted as indices of the orienting response. In heart rate two easily identifiable components are usually present, i.e., heart rate acceleration and heart rate deceleration. The galvanic skin response consists usually of frequency and amplitude changes, both reflecting an increase in skin conductance. Heart rate acceleration and increase in skin conductance have traditionally been regarded as indices of both the orienting response and emotionality. However, Lacey (1959) has suggested that the control conditions or context of the task in which heart rate acceleration and increase in skin conductance occur distinguishes the orienting from the emotive response.

Lacey (1959) proposes that deceleration of heart rate indicates attention to external events, and heart rate acceleration indicates attention to internal events. He describes in some detail the relationships between HR and GSR under varying task conditions. When the subject's attention is directed towards external events (when

environmental stimuli are accepted), heart rate deceleration and an increase in skin conductance are observed together. However, when the subject's attention is turned inwards (environmental stimuli rejected), heart rate accelerates and skin conductance increases. This he terms "directional fractionation". A number of studies support his hypothesis (Tursky, Schwartz & Crider, 1970; Schwartz, 1971). Porges and Raskin (1969) noted that when college students were asked to attend to an internal task such as covertly counting their own heart beats, acceleration of heart rate occurred.

Hahn (1973), Elliott (1972) and Obrist, Webb, Stutterer and Howard (1970) have all presented critical appraisals of the Lacey hypothesis. They criticize the implications that heart rate deceleration facilitates certain kinds of sensory-motor performance (specifically reaction time). Studies of reaction time (RT) have noted that heart rate deceleration occurs immediately after the warning signal in the preparatory period preceding the imperative signal (Lacey, 1967). However, Obrist, Webb, Stutterer and Howard (1970) blocked the cardiac decelerative response pharmacologically in a group of subjects and found that such blockage did not affect their reaction time performance relative to a control group. Thus, Elliott (1972), on the basis of this and other contradictory evidence, questions Lacey's suggestion that heart rate deceleration facilitates sensory-motor performance through cortical excitation.

In one study (Lacey, 1970) the heart rate deceleratory response was found to have a high positive correlation with the "contingent negative variation" response, which is characterized as a measure of

an organism's readiness to respond. Thus, "expectancy" to perform a task or detect a significant event seems to be indicated by heart rate deceleration. The concept of "readiness to respond" appears to be what Denny (1966) refers to when he suggests that the retarded lack the ability to produce "self-initiated sets". He suggests that the retarded cannot initiate a set or "readiness to respond" as easily as the normal, the reason being that the retardate is more "stimulus bound" than is the normal, ". . . more at the beck and call of each and every stimulus change (Denny, 1966, p. 5)". In a vigilance task, with its variety of nonsignal background events, the mental retardate would then display more "false alarms" than would the CA matched normal. Also, the mental retardate would be expected to display indiscriminate orienting response to the stimuli when not carefully instructed to attend to the signal stimulus (Luria, 1971) or to rehearse (Ellis, 1970).

It is well established that central factors control changes in GSR and heart rate. Theoretical support is obtained in the work of Sokolov (1963, 1965, 1969) on the orienting response. Bernstein (1969) has hypothesized that such central control is vital in eliciting the GSR and has specifically assoicated it with the assessment of the significance of impinging stimuli. In a more recent paper, Bernstein (1975) found that consistently greater GSRs are elicited by signals which have high significance than by physically identical signals which lack such significance. Bernstein (1975) goes on to speculate that any signal to which a subject listens may take on alerting qualities. In this sense, then, alerting is broadened to mean just listening or "taking in".

He suggests that vigilance tasks might elicit a group of "alerting" or "taking in" responses whose differences in amplitude reflect the significance of what is taken in, and an execute response separate from these. Within a vigilance task, then, the nonsignals would produce a small magnitude of GSR, whereas the signals would produce a greater magnitude of GSR. The imperative signal might produce a response separate from these. If the mentally retarded do not apprehend the significance of certain stimuli in a vigilance task, then their GSRs should be smaller in magnitude to the more significant stimuli than a group of normals. This may assist in delineating more clearly deficits in "attention" as was suggested previously.

Vigilance

This study will make use of a vigilance task as a method of obtaining information with respect to the selectivity component of "attention". The reader is referred to books by Broadbent (1958, 1971) and Mackworth (1969, 1970) for a more comprehensive coverage of this area than can be given here.

Vigilance research is basically concerned with the attentiveness of the subject and his ability to detect changes and select a signal stimulus in stimuli events over a reasonably long period. There are a variety of theories directed towards explaining vigilance behavior. They extend through cortical inhibition, signal theory, expectancy, activation and

habituation of arousal. All these theories attempt to explain the decrement in performance noted as the vigilance task proceeds. The decrement in performance includes increase in false alarms and omissions.

Inhibition theory

Mackworth (1950) put forth a hypothesis that the decrement in performance observed was due to inhibition, the basic explanation being that the highly repetitive and monotonous nature of the task produced internal inhibition related to Pavlov (1924) and cortical inhibition. One would expect from this explanation that total experimental extinction will occur. However, as Frankman and Adams (1962) point out, this is not the case. In the vigilance task there is initially an increase in false detections which gradually falls off and a level is reached at which the increase is noted to stop (Frankman & Adams, 1962). Therefore, there appears to be some reluctance in accepting an inhibition explanation.

Filter theory

Broadbent (1958) interpreted vigilance in terms of "attention", the basic contention being that the subject will select only certain stimuli from the situation because of a "limited processing capacity", and also because adequate response to one part of the situation is incompatible with adequate response to another part. The decrement in performance, then, is a function of competition of stimuli. One of the factors governing whether or not the source of information would be selected was the novelty of the information. Thus, as the task progressed there would be periods in which the nervous system would be

involved with information other than the task itself and decrement in performance would therefore occur.

Expectancy theory

The essence of this approach to vigilance is that the response to a signal becomes more likely if the signal is more probable, the probability being derived from past incidence of the signals (Deese, 1955). Changes in expectancy would therefore give rise to changes in performance as the vigilance task proceeds. Because the events do not become more probable, decrement in performance is noted.

Habituation theory

Mackworth (1969) discussed the decrements of performance in a vigilance task in terms of habituation of neural responses to the background events of the task. The decrement is thought to occur as a result of habituation of the arousal response and also habituation of the evoked potentials produced by the repetitive, continuous or unchanged stimuli that constitute the background events of the task. Therefore, as a result of the habituation of the arousal response, sensitivity decreases, while habituation of the evoked potential will result in a decrease of positive motor responses to both background events (false alarms) and to the signals (correct detections).

Considerable evidence is advanced by Mackworth (1969, 1970) in support of the argument. Some of these are given below:

1. Habituation depends on repetition of a stimulus or series of stimuli, as does decrement in performance on a vigilance task in terms of repetitive background events.

2. The rate of habituation is faster with a faster event rate. When the background event rate is increased, there is a marked reduction in the probability of detection of a signal throughout the task.
3. Presentation of a different stimulus results in recovery of the habituated response. Alternation between visual and auditory modes produce considerable improvement in performance. Mackworth (1969), in concluding, suggests that ". . . it is better to determine as widely as possible the various concomitant changes in the physiological and psychological responses of the subject . . . (p. 198)".

One study (Das & Bower, 1971a) compared normals and retardates in a 30 minute vigilance task using GSR as a measure. The task consisted of two signal and four nonsignal words. One of the signal words served as a warning signal, preceding the other, which was an imperative signal for button pressing. Habituation of GSRs occurred at the same rate for both groups. The warning signal, however, evoked a greater number of GSRs in the normals than the imperative one. The opposite was the case for the retardates. In this study, however, the task of just listening for a signal word appeared to be too simple to produce any gradual decrement in button pressing. Also, HR was not taken concurrently with GSR in the study. As Sroufe (1971) suggests, ". . . time locked cardiac slowing is an index of ability to maintain attention (p. 342)". Therefore, heart rate should be a very sensitive indicator of task demand and interactions of stimulus and response as was suggested before.

Coles and Gayles (1971) attempted to determine the value of physiological activity as predictors of performance in a vigilance task. Their study involved 22 male undergraduate students. The task was a one hour

vigilance task which required subjects to make a discriminative response to the last digit of a sequence of three consecutive odd digits (signal sequence), which occurred among a string of random digits from 1 to 9. The results indicated that the subjects who reacted quickly and gave persistent GSRs to the series of identical stimuli displayed more efficient vigilance performance. Also, one measure of habituation and overall detection was found to be related. The indication was that measures of habituation, i.e., number of trials before three no responses (GSRs), was significantly correlated with overall detections (rho = +.461, $p < .05$). However, the physiological measures in this study were not taken concurrently with vigilance performance. The difference in task demands themselves will confound the results (Lacey, 1959). There is, however, some support in this particular study for Mackworth's (1969) hypothesis of arousal response habituation and vigilance decrement.

Other studies have also suggested that habituation of the GSR component of the OR and vigilance decrement are related. Skin conductance shows a decline during tasks in which decrement occurs (Davies & Krkovic, 1965; Eason, Beardsall & Jaffee, 1965). Also, Surivillo and Quilter (1965) found that the frequency of spontaneous GSRs are greater prior to detections than prior to omissions. However, Ross, Dardona and Hackman (1959) classified their subjects according to the type of skin conductance trend observed (either ascending, descending or cyclical), and failed to find any relationships between type of trend and detection efficiency. Few of these findings, however, have considered both the heart rate component and GSR simultaneously within the vigilance task, and few have utilized a mentally retarded population which may be

useful in delineating the characteristics of OR habituation and vigilance.

CHAPTER III

RATIONALE AND HYPOTHESES

Rationale

Numerous studies of "attention" in mental retardation have been carried out (cf. Luria, 1963; O'Connor & Hermelin, 1963; Ellis, 1963; Zeaman & House, 1963; Crosby, 1972; Das & Bower, 1971). The findings to date have been inconsistent. The literature is almost nonexistent with respect to studies of vigilance task performance and concomitant autonomic responses in the mentally retarded. There have in particular been few studies conducted which have specifically taken continuous measures of heart rate and galvanic skin response in a vigilance-type paradigm utilizing *meaningful* verbal stimuli.

Studies which have considered vigilance performance of mental retardates have generally found lower levels of vigilance performance for the mentally retarded as compared to CA matched normals (cf. Semmel, 1965; Das & Bower, 1970, 1971). This has been attributed to differential patterns of arousal between normals and retardates (Semmel, 1965). Clausen (1970) has suggested that the mentally retarded do not control their level of arousal to the same extent as normals and that they do not anticipate events. He also indicates that the mentally retarded cannot muster arousal in preparation for critical moments and are therefore more highly dependent on the arousal characteristics of the stimuli than are normals. As reviewed earlier, results of studies considering arousal differences indexed by basal skin conductance have

found inconsistent results. Evidence can be mustered for either lower or higher levels of arousal depending on the bias of the reviewer. One of the most effective paradigms in which to more clearly examine the "attentive process" in the mentally retarded would be a vigilance task in which a behavioral measure of selective attention could be obtained in conjunction with autonomic response measures which may more clearly delineate the selectivity and arousal components of "attention". As Sroufe (1971) has suggested:

> The convergence of autonomic and performance measures of maintenance of set, distractibility, activity level and lability, vigilance and impulse control should make it possible to tease apart various components of what has previously been called attention . . . studies using children with known "attention" deficits, provide a fruitful approach to the problem (p. 343).

This study, therefore, has two specific purposes:

1. To investigate differences in vigilance performance in retardates and normals and the concomitant physiological changes of heart rate and GSR as these relate to the selectivity component of "attention".
2. To explore Luria's (1971) suggestion that habituation of OR in retardates can be resisted through specific instructions to attend to signal stimuli.

A secondary purpose is to gather data on the possible relationship of habituation of the orienting response and vigilance decrement as suggested by Mackworth (1969).

Definitions

<u>Orienting response</u>

A system of autonomic, skeletal and other changes involving the whole body, which constitute a reliable reaction to the stimulus

condition of disparity between a neuronal model and stimulus. The response habituates under continuing or regularly repeated presentation of a stimulus. Also considered a response in components of HR and/or GSR.

Component of the orienting response

Any of the sympathetic, skeletal or sense organ changes (e.g., heart rate deceleration, eye movement, galvanic skin response) which is a regular constituent of the constellation of responses recorded which comprise the orienting response. The components of OR in this study were heart rate and the galvanic skin response.

Phasic response

A rapid change in a component of the orienting response which returns within a few seconds to the original level, and which is a response to some change in the environment.

Tonic response

A comparatively slower change in a component of the orienting response, which persists longer than the phasic response, and which is a response to change in the environment.

Habituation

Decline in amplitude of the orienting response as a function of repeated or continuous presentation of the same stimulus. The decline may continue to the point where no response occurs at all.

Arousal

A generic term representing a continuous variable which is indicative of the state of an organism's psychophysiological activity. Such activity may range from deep sleep at one end to extreme excitement at the other.

Vigilance decrement

Decrease in correct detection of signal stimuli as well as increase in false alarms.

Instructed

A group of mentally retarded Ss who are required to overtly rehearse "MAN BOY MAN Press" throughout the session.

Noninstructed

A group of mentally retarded Ss who are not required to rehearse but are only given instructions to press a key when they have heard the signal sequence MAN BOY MAN.

Hypotheses

The following hypotheses relate to two basic comparisons, i.e., normal-noninstructed and instructed-noninstructed. Hypothesis 1 deals with vigilance behavior, Hypothesis 2 with the GSR, and Hypothesis 3 with heart rate.

Vigilance performance

The vigilance task utilized here can be expected to result in a lower level of vigilance performance for the noninstructed as compared to the normals (Das, 1970; Semmel, 1965). The task is reasonably complex and if the theory proposed by Ellis (1970) suggesting a deficit in short-term memory in the retardate is correct, then a greater number

of false detections for the noninstructed group as compared to the normals would be anticipated. The reason for this would be in regard to the nonsignal sequences. The nonsignal sequence CAT BOY MAN would give rise to false detections as the first word in the sequence having been lost from memory the noninstructed retardate presses the key as he is unsure of the sequence, but probably remembers the last signals. The other nonsignal sequences might also give rise to false detections as the noninstructed would press only upon hearing one of the signal words, perhaps MAN, as it is the most prevalent signal (appearing twice in the sequence).

On the basis of Luria's (1963) hypothesis regarding the presence of a verbal-motor dissociation in the retarded, one would expect the noninstructed to also display more omissions (failure to respond to the signal sequence) than the normals.

The instructed group, because they have been instructed to rehearse (Ellis, 1970) and/or verbally mediate (Luria, 1971), can be expected to perform significantly better than the noninstructed group (fewer omissions and false detections). The effect of instructions should result in a more selective responding for the retardate with respect to signals and nonsignals.

On the basis of the above, the following hypotheses were formulated:

Hypothesis 1. The noninstructed group will display a lower level of vigilance performance (greater number of omissions and false detections) as compared to the normal group.

Hypothesis 1.1. The instructed group will display a higher level of vigilance performance (fewer omissions and false detections) as

compared to the noninstructed group.

Most vigilance studies indicate a decrement in performance as the task proceeds (Mackworth, 1969). This decrement is often observed as increasing false detections and/or omissions.

Hypothesis 1.2. All three groups will display a decrement in vigilance performance over the session.

Autonomic responses during vigilance

The present vigilance task involves a considerable number of trials and is reasonably long. One might therefore expect habituation of heart rate and GSR to occur in all three groups (Mackworth, 1969). However, if one considers Luria's (1963) suggestion of rapid habituation of orienting response in the retarded, the noninstructed group can be expected to display OR habituation (decrease in per cent deceleration of heart rate and GSR) more quickly to the signal sequence than either the normals or the instructed group.

Heart rate deceleration being a highly sensitive indicator of sustained attention (Sroufe, 1971), and the suggestion of many writers of an "attentional deficit" in the retarded (Zeaman & House, 1963; Luria, 1963; Meldman, 1970; Wolitzky *et al*., 1972) indicates that the noninstructed would display less heart rate deceleration to the signal sequence than the normal group. If the mentally retarded are deficient in the selective component of attention, this should be displayed in their HR and GSR responses to signal and nonsignal sequences.

On the basis of the above, the following hypotheses were formulated:

Hypothesis 2. The noninstructed mentally retarded will display a

faster rate of habituation of GSR to the signal sequence than the normals.

Hypothesis 2.1. The noninstructed mentally retarded will display a faster rate of habituation of GSR to the signal sequence than the instructed.

Hypothesis 2.2. The normals will display a greater magnitude of GSR to the signals as compared to the noninstructed.

Hypothesis 2.3. The instructed mentally retarded will display a greater magnitude of GSR to the signals as compared to the noninstructed.

Hypothesis 2.4. The instructed mentally retarded will display less magnitude of GSR to nonsignals as compared to the noninstructed.

Hypothesis 3. The noninstructed mentally retarded will display a faster rate of habituation of heart rate deceleration to the signals as compared to the normals.

Hypothesis 3.1. The instructed mentally retarded will display a slower rate of habituation of heart rate deceleration to the signals as compared to the noninstructed.

Hypothesis 3.2. The normal group will display greater deceleration of heart rate to the signals than the noninstructed mentally retarded.

Hypothesis 3.3. The instructed mentally retarded will display greater deceleration of heart rate to the signals as compared to the noninstructed.

CHAPTER IV

METHOD

Subjects

Two populations were involved in the study, i.e., normal children and educable mentally retarded children. The normal children were volunteers from two City junior high schools. Children whose school records suggested evidence of sensory, emotional or organic anomalies or medically diagnosed skin conditions were excluded. The records of five subjects were not included in the final sample, three due to incomplete data and failure in the operation of apparatus and two randomly discarded to achieve equal Ns for analysis purposes. The final sample comprised 15 children having a mean chronological age of 14.1 years (SD = 0.8 years) and a mean intelligence quotient of 113 (SD = 8.9) as reported in their school records. All subjects were males.

The EMR children were from a special school in the City. Initially, 140 children were identified. The vice-principal of the school and the teachers were then interviewed to eliminate those children with suggested emotional or sensory impairments. The school records of the children were scanned also to eliminate those children with medically diagnosed skin conditions or heart problems. Then, letters were sent to their parents or legal guardians to obtain written consent for their child to participate in the experiment. Five subjects were omitted from the final analysis; four because of movement artifacts and one because of equipment failure. The final sample comprised 30 children with IQs between 50-70 with a mean IQ of 66.8 (SD = 4.8) and a mean CA of 14.5 years (SD = 0.7).

All subjects were males. These 30 children were then randomly assigned to two conditions (instructed and noninstructed), 15 Ss in each condition.

Apparatus

A Hewlett-Packard model 1500 polygraph was used for recording galvanic skin responses and heart rate responses. Three channels were utilized:

1. to measure the galvanic skin responses
2. to measure the heart rate
3. to record the audio-signals from the tape recorder.

Also, provision was made for marking on the polygraph paper when a motor response (key press) had been made. This was done automatically. The paper ran at a constant speed of 5mm/second, making it possible to determine the temporal location of each stimulus presentation and response made.

To obtain galvanic skin response readings, silver-silver chloride electrodes 0.5 inches in diameter were attached to the subject's left palm, back of the left hand and a ground placed approximately 8 inches from the wrist of the left arm. The heart rate measures were obtained from silver-silver chloride electrodes placed on the sternum and the third rib on the left side of the body. The flat electrodes were filled with Beckman paste and attached by electrode adhesive collars.

The auditory stimuli and instructions were supplied through a speaker on the wall, located above the subject's head. The subject sat in a padded chair (leatheretter), separated from the experimenter by an electrically shielded, soundproof room. Artifacts resulting from

movement could be detected from a one-way mirror built into the booth and were marked on a subject's record.

Vigilance Task

Stimulus materials

The task used words as signals. It was therefore of a more cognitive kind, different from the conventionally used sensory stimuli of tones, light flashes, etc. Interspersed between the signal sequence MAN BOY MAN and the nonsignal sequences MAN BOY CHAIR, MAN KEY MAN and CAT BOY MAN were the nonsignal stimuli CAT, KEY, COW and HEN. The interstimulus intervals were 16 seconds to allow for the autonomic measures of heart rate and galvanic skin response to be recorded. Figure 1 displays a typical block (5 minutes) of stimuli presentation. The complete task was prerecorded on tape and was 30 minutes in length. Upon hearing the last MAN in the sequence MAN BOY MAN, the subject was required to press a key to indicate detection of the signal sequence. The paradigm used in this study was similar to that utilized by Coles and Gale (1971), except that subjects in their study were required to produce a motor response for both stimulus signal and nonsignal and the signal stimulus was a series of odd numbers.

The above material was an adaptation of a complex vigilance task utilized by Das (1970). The task in his study consisted of a random presentation of the words BABY BOY HAND FOOT TABLE CHAIR and the numbers 1 3 5 6 7 9. The signal words were BABY, HAND and TABLE. This task resulted in a quite sensitive measure of vigilance between a group

Fig. 1. A typical five-minute block of stimuli utilized in the vigilance task

nonsignal sequence ——— CAT ——— BOY ——— MAN ——— COW ——— HEN

nonsignal sequence ——— MAN ——— KEY ——— MAN ——— COW ——— KEY

signal sequence ——— MAN ——— BOY ——— MAN ——— HEN ——— COW

nonsignal sequence ——— MAN ——— BOY ——— CHAIR ——— KEY ——— MAN

signal sequence ——— BOY ——— MAN ——— CAT ——— COW ——— HEN

Note: ——— indicates interstimulus intervals of 16 secs

of mildly retarded (mean IQ 66.10) and severely retarded (mean IQ 47.85). The task utilized in this study was somewhat more complex as the _S_ was required to respond to a sequence of signals rather than to one of three signals. Also, the nonsignal sequences become quite potent distractors of the signal sequence. It was expected, therefore, to differentiate the group of normal and noninstructed mentally retarded.

Instructions

It was mentioned previously that three groups were involved in the study (i.e., a normal group and two groups of mentally retarded subjects). The instructions given to the group of normal subjects and the group of 'noninstructed' mentally retarded subjects were: "You are going to hear a series of words; whenever you hear the sequence MAN BOY _MAN_ you are to press the key when you hear the last word MAN. Only press the key when you hear this sequence, MAN BOY _MAN_. Do not press for any other. Okay, now let's try it." (Subject given a few nonsignal words and signal sequence.) If he was right, the experimenter said, "Good, that's right. Now let's try another." If the subject pressed incorrectly, the experimenter would say, "No" and then repeat the instructions. When three consecutive correct responses were made, the experimenter would say, "Okay, now I'm going to let you go on your own."

The 'instructed' group of mentally retarded subjects was specifically instructed to rehearse (Ellis, 1970) and/or verbally mediate (Luria, 1963, 1971). The instructions to this group were: "You are going to hear a series of words; whenever you hear the sequence MAN BOY _MAN_ you are to press the key when you hear the last word _MAN_. Only press the

key when you hear this sequence, MAN BOY MAN. Do not press for any other. Say out loud: MAN BOY MAN. PRESS! MAN BOY MAN. PRESS! Let me hear you. Keep saying this over and over all the time you are here. MAN BOY MAN. PRESS! Do not stop. Okay, now let's try it." The same procedure was then followed as in the last phase of instructions for noninstructed and normal groups, i.e., three consecutive correct responses obtained before continuing with the task. As a result of these instructions, the mentally retarded group here were expected to perform better on the vigilance task than those in the noninstructed treatment. (See Appendix G.)

Procedure

The experiment was conducted in an electrically shielded, soundproof room with temperature control of 70°F. The mentally retarded subjects from the special school were transported to the University by taxi. Normal subjects walked from a junior high school two blocks from the University. Eight of the normals participated in the morning and seven participated in the afternoon. This was also counterbalanced for the two mentally retarded groups.

When they entered the laboratory, all subjects were given a general description of the apparatus and permitted to ask questions about the equipment. Following two or three minutes of such discussion, the subject was seated in a comfortable reclining leatherette chair with wide arms, while the experimenter described the attachment of the galvanic skin response and heart rate electrodes. The sites of electrode placements were then prepared and electrodes attached.

The subject was then given the key in his right hand and it was explained that he would be required to press the key after hearing certain words over the loudspeaker above his head. In all, a minimum of 10 minutes elapsed between attachment of electrodes and the beginning of the task. This was the period of time taken for stabilizing the heart rate and galvanic skin response readings. The total time taken from the time of electrode placement and end of the task was a maximum of 45 minutes.

Scoring

Galvanic skin response measures

Second-by-second conductance change. Difference between mean conductance observed at 1 second intervals for the 2 seconds immediately preceding stimulus onset and ten 1 second intervals following stimulus onset. In this study there were ten different scores obtained for each subject for a stimulus.

Magnitude. Maximum change in (natural) logarithm conductance, within the 1 to 5 second period immediately following stimulus onset.

Frequency. Number of scorable galvanic skin responses. Each subject given a score of 1 if the downward pen deflection is equivalent to or greater than 500 ohms. Response must occur between 1 and 5 seconds after stimulus onset.

Heart rate measures

Second-by-second BPM change. Difference between the mean beats per minute observed at 1 second intervals for the 2 seconds immediately preceding stimulus onset and the ten 1 second intervals following stimulus onset.

Per cent deceleration. Percentage decrease in heart rate: % decrease = 100 x (prestimulus beats per minute, less the mean of the two lowest beats per minute in the next 5 seconds. This is then divided by the prestimulus beats per minute). (See Appendix A, p. 144.)

Per cent acceleration. Percentage increase in heart rate: % increase = 100 x (highest beats per minute between fourth and tenth second following stimulus-prestimulus beats per minute) / prestimulus beats per minute. (See Appendix A, p. 144.)

Vigilance performance

Omission. Failure to press the key after hearing the imperative signal MAN in the signal sequence MAN BOY MAN.

False detection. A key press for the signal MAN in any position other than that for the imperative signal MAN in the signal sequence MAN BOY MAN.

All data from the galvanic skin and heart rate response recordings were manually scored in terms of the definitions listed above. Data were scored for all signal and nonsignal sequences. The response measures were transferred to punched cards and then to magnetic tape for analysis.

The measures of galvanic skin response for each subject were:

1. Ninety frequency scores, one for each stimulus in the signal and nonsignal sequences.
2. Ninety magnitude scores, one for each stimulus in the signal and nonsignal sequences.

3. Ten <u>conductance change</u> scores, for each stimulus in the signal and nonsignal sequences (900 in total).
4. Ninety mean <u>prestimulus conductance</u> level scores, one for each stimulus in the signal and nonsignal sequences.

The measures of heart rate response for each subject were:

1. Ten <u>beats per minute change</u> scores for each stimulus in the signal and nonsignal sequences (900 in total).
2. Ninety <u>% deceleration</u> scores, one for each stimulus in the signal and nonsignal sequences.
3. Ninety <u>% acceleration</u> scores, one for each stimulus in the signal and nonsignal sequences.
4. Ninety mean <u>prestimulus heart rate</u> level scores, one for each stimulus in the signal and nonsignal sequences.

The vigilance performance measures for each subject were:

1. Number of false detections for each five-minute block of time.
2. Number of omissions for each five-minute block of time.
3. Total number of false detections over the session.
4. Total number of omissions over the session.

Rationale for Response Measures

There is a continuing debate concerning the most appropriate measures for many of the physiological responses. As far as the galvanic skin response is concerned, the common practice is to measure the amplitude of GSR (Darrow, 1964, 1967; Haggard, 1949; Martin, 1964). Magnitude was preferred to amplitude in this study because amplitude is considerably affected by missing scores which tend to occur with habituation.

Magnitude, because it takes into account zero responses in reaching a mean, would therefore be a more sensitive measure than amplitude, which ignores zero responses.

Prokasy and Kumpfer (1973) in their discussion of GSR measurement suggest that it is most appropriate to obtain more than one measure of GSR in order to examine relationships which may exist among the different measures. The measures therefore used in this study were frequency magnitude and second-by-second conductance change.

A second-by-second analysis of conductance change was taken in order to look at the meaningful relations existing between galvanic skin response and the experimental manipulations. Graham and Clifton's (1966) discussion of heart rate analysis points out the importance of looking at second-by-second and trial-by-trial heart rate changes in order to elucidate the meaningful relations between heart rate change and the experimental variables. This could also be said of the galvanic skin response measures.

One difficulty surrounding heart rate and GSR measures is the problem stated in the "Law of Initial Values" (Lacey, 1959). The "law" states that response to an excitatory stimulus decreases and responses to an inhibitory stimulus increases as the level of activity of stimulation increases. This seems to mean that whether stimuli generally evoke heart rate acceleration or generally evoke heart rate deceleration, the change from high prestimulus levels will be negative. However, Graham and Jackson (1970) studied this phenomenon in some detail. They suggest that when the only interest lies in the direction of heart rate change, it usually proves satisfactory to use unadjusted difference

scores. As the present study was concerned primarily with the direction of change, i.e., heart rate deceleration and acceleration, it does not seem inappropriate to use the unadjusted difference score as one of the measures of heart rate. However, this was checked further in the analysis to detect possible group prestimulus differences.

Tonic vs. phasic measures

Sokolov (1963, 1965, 1966) distinguishes between two phases or aspects of the orienting response:

1. phasic response
2. tonic response.

The phasic form of the response is related to a "rapid activation of the analyzers in response to change in the environment (Sokolov, 1965, p. 143)". It is brief in duration and develops rapidly. The tonic reaction is slower in development and persists for a longer period of time, and is not clearly manifest externally.
The present study used both phasic and tonic measures of the orienting response to allow for examination of both the rapid changes occurring and the slower, more gradual changes observed in the tonic responses.

Materials Utilized to Minimize Electrode Polarization

The techniques utilized to reduce electrode polarization in this study followed those suggested by Martin (1964):

1. A two-element electrode was utilized (one to carry the constant current, the other to act as a voltage probe.
2. Beckman electrode paste, consisting essentially of NaCl, was used.
3. Electrodes were constructed of silver-silver chloride.

CHAPTER V

VIGILANCE PERFORMANCE: RESULTS AND DISCUSSION

The vigilance performance of the three groups (normals, instructed and noninstructed) was evaluated using the number of false detections and omissions as the dependent variables. The 30-minute vigilance performance was divided into six five-minute blocks in order to observe changes in performance as a function of time on task. False detections were marked for an S if he pressed the key for the signal word MAN in any position other than at the end of the signal sequence MAN BOY MAN. There were six possible false detections per block. Omissions were scored if the S failed to press the key after hearing the imperative signal MAN at the end of the signal sequence. There were 12 possible omissions over the total session, with two possible omissions in any one block.

The noninstructed were expected to display a greater number of false detections in the vigilance task than either the normals or instructed (Denny, 1966). Differences in performance with respect to numbers of omissions were also anticipated (i.e., the noninstructed group committing more errors of omission than either the normal or instructed groups) (Luria, 1963).

The block-by-block numbers of false detections and omissions, as well as the total errors for each group, are presented in Tables 1a and b. It was quite evident that the noninstructed group displayed greater numbers of omissions and false detections as compared to the normals. The data for the normal group did not allow for statistical analysis to

Table 1a

Total Number of False Detections in Vigilance

Group	Blocks (5 min. each)						Total
	1	2	3	4	5	6	
Normal (N = 15)	0	0	1	0	1	2	4
Noninstructed (N = 15)	26	25	27	20	20	22	140
Instructed (N = 15)	7	8	11	10	13	9	58

Table 1b

Total Number of Omissions in Vigilance

Group	Blocks (5 min. each)						Total
	1	2	3	4	5	6	
Normal (N = 15)	3	1	1	0	1	0	5
Noninstructed (N = 15)	10	11	13	8	10	7	59
Instructed (N = 15)	2	1	2	3	4	6	18

be performed with this group as there was a ceiling effect evident for the task. The ease with which the normal group performed on the task is quite evident, as they made only four false detections and five omissions in total over the entire session. The noninstructed group, on the other hand, scored a total of 140 false detections and 59 omissions over the session. This supports the results obtained previously, which indicated that mentally retarded subjects displayed inferior vigilance performance as compared to normal subjects of equivalent chronological age (Semmel, 1965; Das & Bower, 1971).

Do instructions to rehearse the signal sequence have an effect on the performance of the mentally retarded in a vigilance task? This question was answered utilizing 2 (groups) x 6 (blocks) ANOVAs with the last factor repeated. The dependent measures were false detections and omissions.

The results of these analyses are shown in Tables 2a and b. The only significant effect was that obtained for omissions ($F = 7.58$, $df = 1/28$, $P < .025$). The noninstructed group made a significantly greater number of omissions over the total session as compared to the instructed group. The means for the instructed and noninstructed groups were 0.200 and 0.656, respectively. Thus, the instructions resulted in fewer errors of omission for the mentally retarded group. There was no significant effect for false detections observed, although a trend was evident ($F = 3.38$, $df = 1/28$, $P \leq .08$). It would appear that the instructions had the effect of focusing the instructed group's "attention" more closely on the imperative signal MAN in the signal sequence. As a result, they

Table 2a

ANOVA for Instructed vs. Noninstructed:
Number of False Detections over Blocks

Source	df	MS	F	P
Between				
Groups	1	37.36	3.38	NS
Error	28	11.04		
Within				
Blocks	5	0.25	0.41	NS
Blocks x groups	5	0.69	1.11	NS
Error	140	0.62		

Table 2b

ANOVA for Instructed vs. Noninstructed:
Number of Omissions over Blocks

Source	df	MS	F	P
Between				
Groups	1	9.34	7.58	≤.025
Error	28	1.23		
Within				
Blocks	5	0.07	0.24	NS
Blocks x groups	5	0.45	1.50	NS
Error	140	0.30		

made fewer errors of omission. This is quite speculative at this point; however, it may become much clearer in the following chapter in which autonomic responses of the groups to the signal sequence are discussed.

Contrary to many vigilance studies, there was little evidence in this study for a decrement in vigilance performance over the task. Mackworth (1969) has cited a great many studies in which an increase in omissions and a decrease in false detections were observed. The task here appeared too easy to produce a decrement in vigilance performance in the three groups. Other investigators, however, have noted little or no vigilance decrement when utilizing mentally retarded subjects and complex signals and nonsignals (Das, 1970; Das & Bower, 1971).

It is interesting to note that there were virtually no key presses for responses to the stimulus CHAIR in the nonsignal sequence MAN BOY CHAIR. The greatest number of false detections occurred for MAN in the nonsignal sequence CAT BOY MAN (14 for the instructed group; 38 for the noninstructed group). The noninstructed group also tended to press for the signal MAN regardless of position.

Discussion

The above vigilance performance findings support Hypothesis 1 which predicted that noninstructed subjects would display poorer vigilance performance than the normals. The noninstructed group displayed both greater numbers of false detections and omissions as compared to the normals. There was partial support obtained with respect to Hypothesis 1.1

which predicted that instructed subjects would display fewer omissions and fewer false detections than the noninstructed group. The instructed did evidence significantly fewer omissions as compared to the noninstructed group. False detection differences, however, did not differentiate the two groups clearly. A trend was evident, although this did not reach significance in the analysis.

Throughout the session there was no evidence of a decrement in vigilance performance. There was therefore no support here for Hypothesis 1.2 which predicted that there would be a decrement.

Instructions to rehearse the signal sequence did increase the level of performance of the mentally retarded group as they displayed fewer errors of omission. If this was partially a function of focusing the instructed group's "attention" on the signal sequence and in particular the imperative signal MAN, then this should be confirmed in the autonomic measures of GSR and HR, which are examined in the following chapter. The results of those analyses may make clearer the reasons for the performance differences obtained here.

CHAPTER VI

AUTONOMIC RESPONSES TO SIGNAL STIMULI DURING VIGILANCE: RESULTS AND DISCUSSION

Galvanic skin responses and heart rate responses were recorded during a vigilance task which required detection of the signal sequence MAN BOY MAN. Ss were required to press a key in response to the imperative signal MAN to indicate detection of the sequence. The dependent measures for GSR were frequency, magnitude and conductance change over seconds (10 seconds poststimulus). For heart rate the measures were second by second beats per minute (BPM) change from prestimulus level over the 10 seconds poststimulus, % deceleration and % acceleration of heart rate from prestimulus level. These measures were scored for all signal and nonsignal sequences. To elucidate changes in GSR and HR responses with repetition, the task was divided into six five-minute blocks of time with the three nonsignal sequences and two signal sequences embedded randomly in each block.

In an attempt to achieve maximum clarity in the presentation of results and to avoid redundancy, the results of analysis for the nonsignal sequences and some specific signal vs. nonsignal comparisons are given in a separate section. Findings which have relevance for certain aspects of the study are incorporated into the results section of particular measures.

The major interest with respect to this study was in the response of the three groups to the signal sequence MAN BOY MAN. A number of questions were raised previously with respect to the three groups. In brief, the major questions with regard to the OR data were:

1. Does the orienting response to a signal sequence display a decrement?
2. Do the mentally retarded display a greater OR decrement to the signal sequence than normals?
3. Do instructions to rehearse the signal sequence increase the levels of the mentally retarded's autonomic responding to the signal sequence, particularly to the imperative signal MAN?
4. Do the mentally retarded's ORs to signals and nonsignals display a lack of selectivity in attention to significant signals?

The first three questions were examined utilizing the response data for the signal sequence MAN BOY MAN. The results of these analyses for GSR will be given first. Normal and mentally retarded comparisons will be followed by the instructed and noninstructed comparisons. The results of the HR analysis will follow the same format.

Prestimulus Levels of Galvanic Skin Response and Heart Rate

The prestimulus level of GSR and heart rate may affect the magnitude of response obtained for a stimulus (Graham & Jackson, 1970). In order to be assured that there were no initial group differences in autonomic responsivity, the prestimulus levels for the signal sequence for the three groups was subjected to a 2 (groups) x 6 (blocks) x 3 (stimuli) ANOVA with the last two factors repeated. No overall significant main effect for groups was obtained (see Appendix B, p. 146).

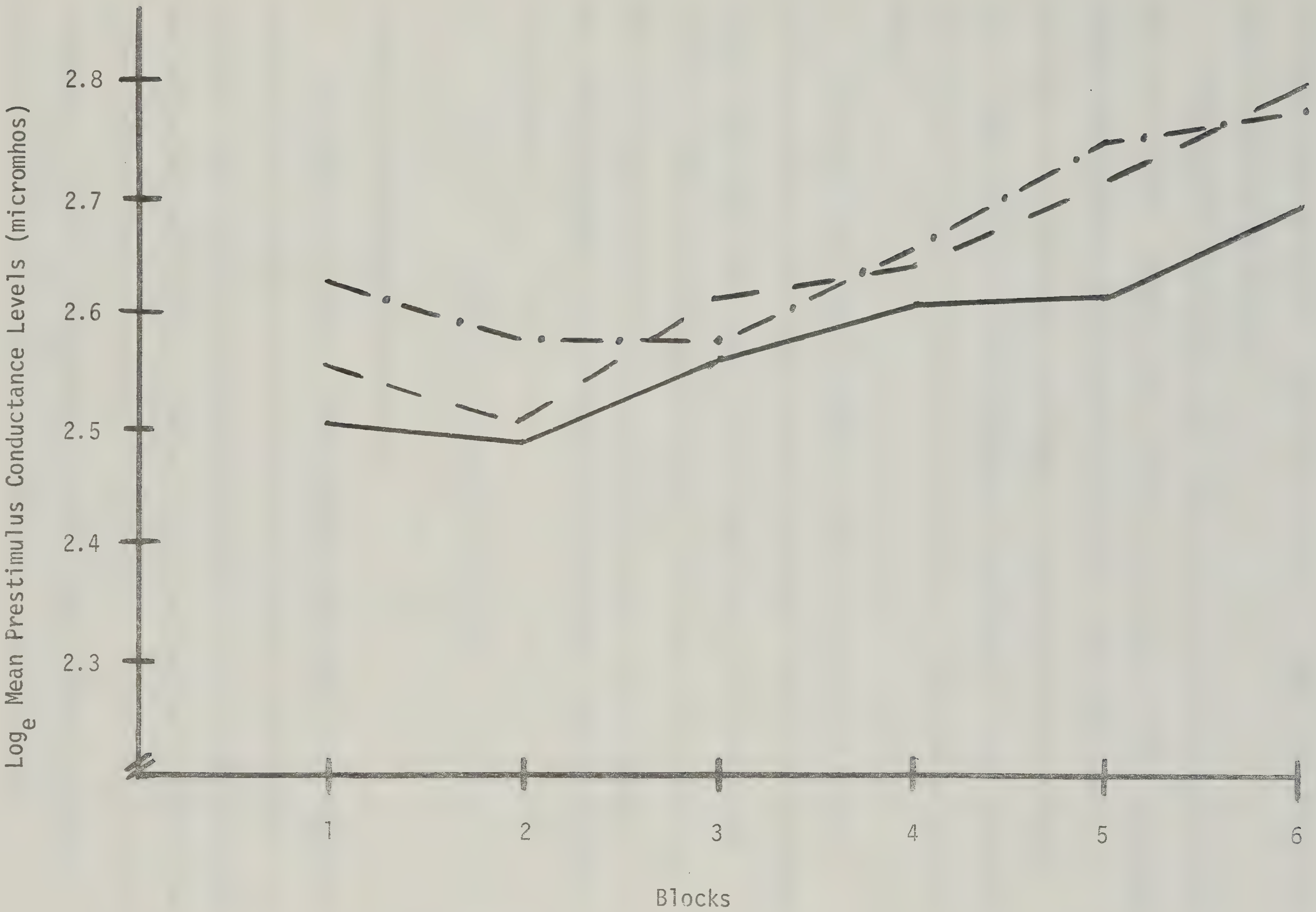
There was however an increase in prestimulus skin conductance levels to the signal sequence over the blocks ($F = 4.96$, $df = 5/104$, $P \leq .01$) for normal and noninstructed groups; this is a somewhat unusual result (see Figure 2). The instructed-noninstructed comparison also

Fig. 2. Mean Log_e prestimulus skin conductance levels for signal sequence over blocks (collapsed over signals) for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


2.8
2.7
2.6
2.5
2.4
2.3
Log$_e$ Mean Prestimulus Conductance Levels (micromhos)
1
2
3
4
5
6
Blocks

yielded a block effect ($F = 3.94$, $df = 5/140$, $P \leq .025$), supporting the trends observed in Figure 2.

The typical finding has been a decrease in skin conductance level (Mackworth, 1969). However, Ross, Dardano and Hackman (1959) and Dardano (1962) have reported that a generally high skin conductance level is associated with little or no decrement in detection performance over time. There is also the finding that when the signal is easy to detect, an increase in arousal as measured by adrenalin is indicated (O'Hanlon, 1964).

In summary, the only significant effect obtained with respect to the prestimulus heart rate and skin conductance levels was an increase in skin conductance over time for all three groups. The heart rate analysis yielded no significant results. Differences that might be obtained between groups in the phasic GSR and heart rate analyses thus would not appear to be a function of prestimulus level differences of the groups.

Galvanic Skin Response Results

Normal vs. noninstructed comparisons

The following normal vs. noninstructed comparisons with frequency, magnitude and second-by-second conductance change as the dependent variables were carried out to test Hypothesis 2.0 which stated that the noninstructed would display a faster rate of habituation of GSR to the signal sequence than the normals. Also examined with the data here was Hypothesis 2.2 which predicted that normals would display a greater magnitude of GSR to the signals as compared to the instructed.

GSR frequency. The frequency of GSR responses to the signal sequence MAN BOY MAN was analyzed in a 2 (groups) x 6 (blocks) x 3 (stimuli) ANOVA, the last two factors being repeated. Table 3 presents the results of this analysis. As expected, a decrease of frequency of GSR response occurred over the six blocks ($F = 3.01$, $df = 5/140$, $P \leq .025$). The means for the six blocks collapsed over groups and stimuli were: 0.70, 0.62, 0.52, 0.51, 0.49, and 0.48. Habituation of frequency of GSR response was therefore evident for both groups. Differences with regard to habituation of GSR frequency of response between the mentally retarded and normal groups were not evident.

The imperative signal MAN in the sequence gave rise to a greater frequency of GSR response for the two groups ($F = 9.63$, $df = 2/56$, $P \leq .001$). The mean response frequencies to the three stimuli arrange themselves in an order relative to the importance of each (0.48, 0.49, 0.69 for MAN BOY MAN, respectively [collapsed over groups and blocks]). The mentally retarded responded in a similar manner to the normals (i.e., with greater frequency of response to the imperative signal MAN in the sequence), even though they had many more omission errors for this signal than the normals.

Magnitude. The $\log_e (x + 1)$ magnitude conductance change measure for the MAN BOY MAN signal sequence was analyzed utilizing the identical format as that described for the frequency data. The results of the ANOVA for this analysis is presented in Table 4. Figure 3 presents the group means collapsed over stimuli for groups.

The block main effect ($F = 2.30$, $df = 5/140$, $P \leq .05$) indicated

Table 3

ANOVA for Normal vs. Noninstructed:
MAN BOY MAN signal sequence; frequency

Source	df	MS	F	P
Between				
Group	1	0.31	0.30	NS
Error	28	1.05		
Within				
Blocks	5	0.70	3.01	≤.05
Blocks x groups	5	0.34	1.48	
Error	140	0.23		
Stimuli	2	2.48	9.63	≤.001
Stimuli x groups	2	0.26	1.00	NS
Error	56	0.26		
Blocks x stimuli	10	0.08	0.49	NS
Blocks x stimuli x groups	10	0.20	1.26	NS
Error	280	0.16		

Table 4

ANOVA for Normal vs. Noninstructed:
MAN BOY MAN signal sequence; magnitude

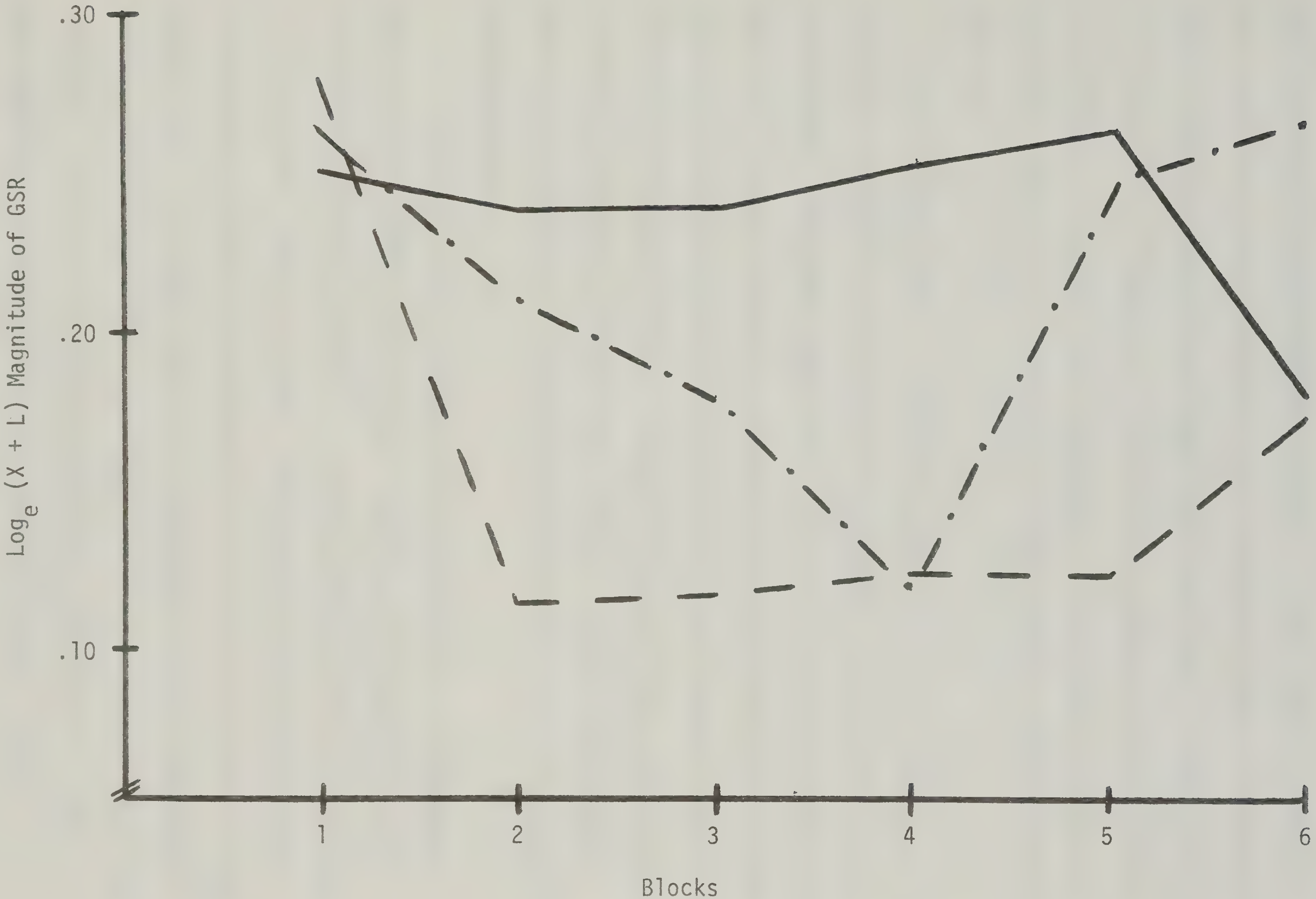
Source	df	MS	F	P
Between				
Group	1	0.66	1.50	NS
Error	28	0.44		
Within				
Blocks	5	0.11	2.30	$\leq .05$
Blocks x groups	5	0.11	2.33	$\leq .05$
Error	140	0.05		
Stimuli	2	1.37	12.83	$\leq .001$
Stimuli x groups	2	0.57	5.36	$\leq .01$
Error	56	0.11		
Blocks x stimuli	10	0.04	0.97	NS
Blocks x stimuli x groups	10	0.02	0.40	NS
Error	280	0.04		

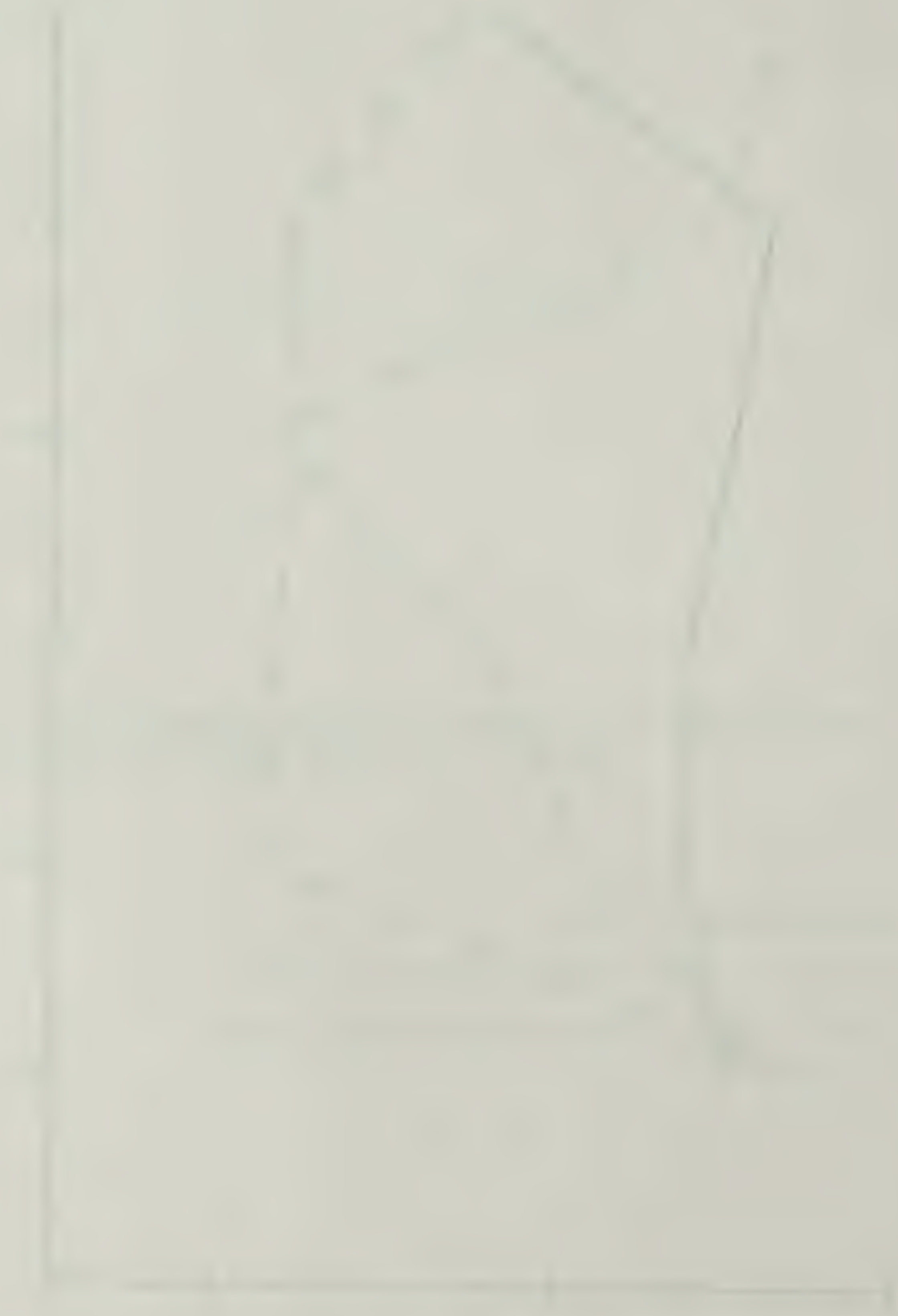
Fig. 3. Mean Log_e magnitude of GSR to signal sequence over blocks (collapsed over signals) for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


.30
.20
.10
Log$_e$ (X + L) Magnitude of GSR
1
2
3
4
5
6
Blocks



that habituation of magnitude of response occurred from the first to the second block, then increased on the fourth and fifth. The means for the six blocks collapsed over groups and stimuli were: 0.26, 0.17, 0.17, 0.18, 0.20, 0.17. Because of irregularities observed on the fifth and sixth blocks, an analysis was carried out on the groups utilizing the first four blocks only. The results of this analysis are presented in Table 5.

The block main effect obtained here ($F = 3.99$, $df = 3/84$, $P \leq .025$) indicates a significant decrement in responding from the first to the second block. The means were 0.26, 0.17, 0.17, 0.18 for the four blocks. The blocks x groups interaction supports the trends observed in Figure 3. The noninstructed decreased the magnitude of their response greatly from the first to the second block, whereas the normals displayed a slight decrement but quickly regained their initial magnitude of response. This may be indicative of faster habituation on the part of the mentally retarded subjects.

The magnitude measure analysis follows that for the frequency analysis in that there was a greater magnitude of response given to the imperative signal <u>MAN</u> than to the first MAN or BOY in the sequence ($F = 10.11$, $df = 2/56$, $P \leq .001$). The means for the three signals collapsed over blocks and groups were 0.14, 0.17, 0.28 for MAN BOY <u>MAN</u>, respectively. The normal group also displayed a greater magnitude of response for the imperative signal <u>MAN</u> than did the noninstructed (see Figure 4). The stimuli x groups interaction yielded an $F = 4.72$; with degrees of freedom at 2/56, the probability was $< .01$.

Table 5

ANOVA for Normal vs. Noninstructed:
MAN BOY MAN signal sequence, magnitude in first four blocks

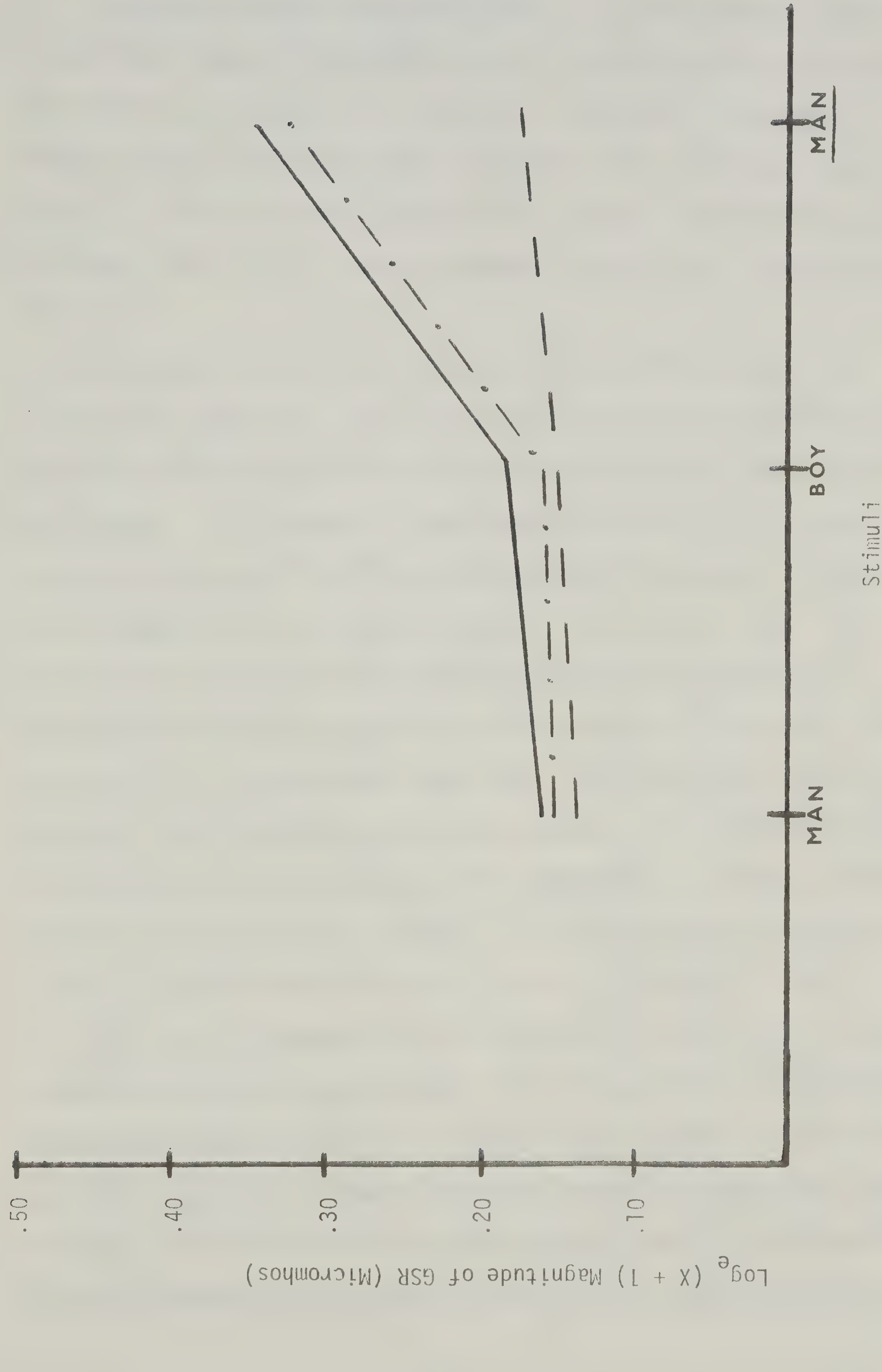
Source	df	MS	F	P
Between				
Groups	1	0.50	1.57	NS
Error	28	0.32		
Within				
Blocks	3	0.18	3.99	≤.025
Blocks x groups	3	0.13	2.87	≤.05
Stimuli	2	0.63	10.11	≤.001
Stimuli x groups	2	0.29	4.72	≤.025
Error	56	0.06		
Blocks x stimuli	6	0.01	0.20	NS
Blocks x stimuli x groups	6	0.02	0.51	NS
Error	168	0.03		

Fig. 4. Mean Log_e magnitude of GSR to signals in signal sequence (collapsed over blocks) for all groups

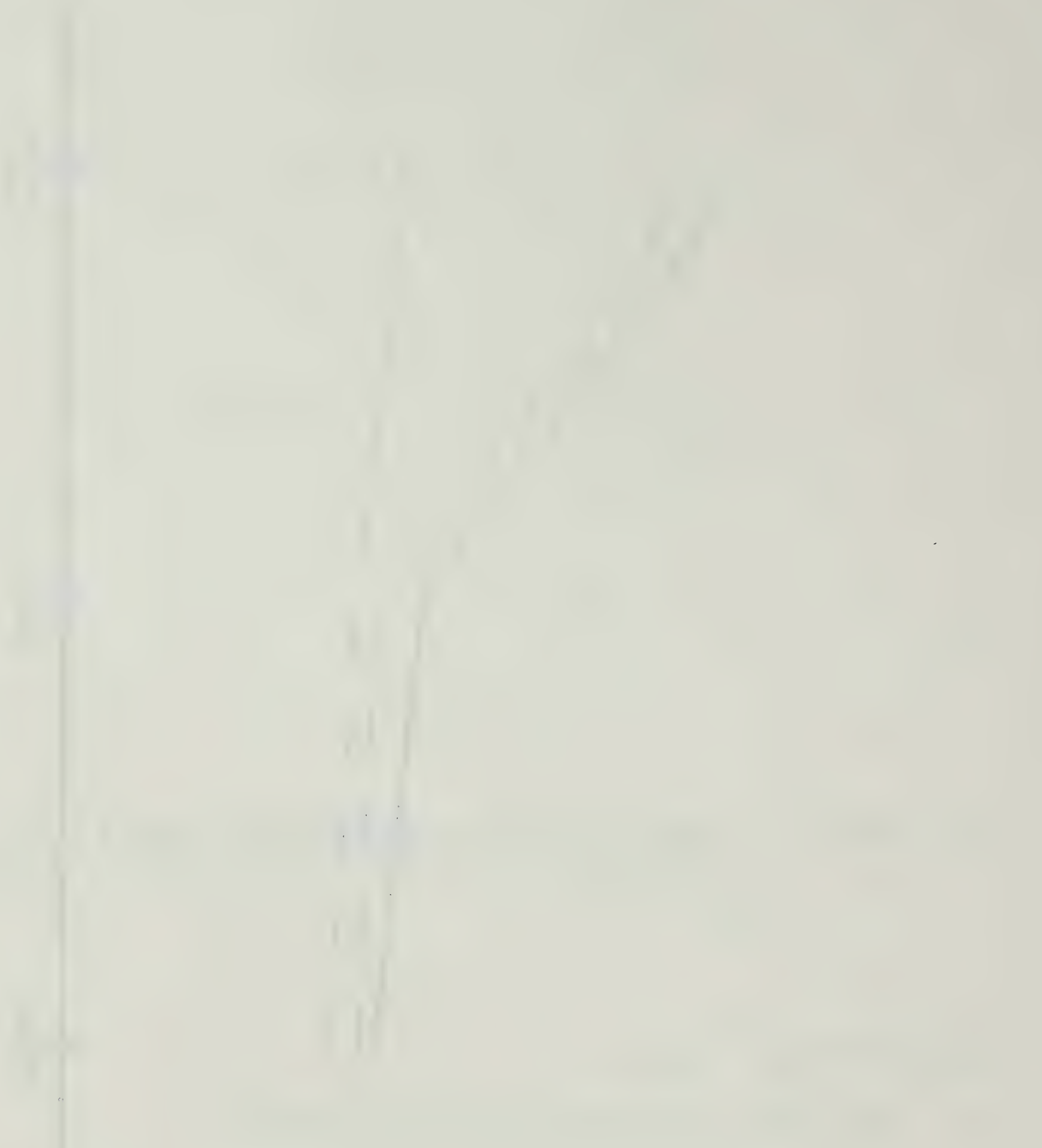
Normal

Mentally retarded instructed

Mentally retarded noninstructed



.50
.40
.30
.20
.10
Log_e (X + 1) Magnitude of GSR (Micromhos)
MAN
BOY
MAN
Stimuli



Second-by-second conductance change. The GSR second-by-second conductance change in micromhos for the 10 seconds poststimulus were analyzed in a 2 (groups) x 6 (blocks) x 3 (stimuli) x 10 (seconds) ANOVA with the last three factors repeated. The results are given in Table 6. Figure 5 presents the main GSR responses for the three groups collapsed over blocks. Figure 6 presents the means for the groups over blocks.

A differential rate of habituation for the three stimuli was evident (see Figure 6). The response to the first MAN in the signal sequence essentially reached a no response level by the fourth block for both groups. The response to the signal BOY displayed more inconsistent results, perhaps as a result of the position of importance it played in the sequence (i.e., a warning signal). It is evident that the imperative signal MAN in the sequence resulted in essentially no habituation of the GSR response for the noninstructed and normal groups, even though the noninstructed group made a great many more errors of omission in the vigilance performance results. The differential rate of habituation of the three stimuli is supported by a blocks x stimuli interaction ($F = 3.02$, $df = 10/280$, $P \leq .01$), as well as the blocks x stimuli x seconds interaction ($F = 2.01$, $df = 90/2520$, $P \leq .001$).

The lack of habituation of the GSR response evident here for the imperative signal MAN may be taken to be a function of key pressing for this signal (which results in a return of OR). However, although this may have some effect, it would seem more appropriate within the context of this task to attribute the effect to a certain extent to the greater degree of signal meaning this particular stimulus had for the two groups. The

Table 6

ANOVA for Normal vs. Noninstructed:
MAN BOY <u>MAN</u> signal sequence; <u>sec x sec</u> GSR

Source	df	MS	F	P
Between				
Groups	1	4.22	2.84	NS
Error	28	1.48		
Within				
Blocks	5	0.96	2.13	NS
Blocks x groups	5	0.68	1.51	NS
Error	140	0.45		
Stimuli	2	4.79	6.48	≤.01
Stimuli x groups	2	0.59	0.80	NS
Error	56	0.74		
Seconds	9	1.15	12.51	≤.001
Seconds x groups	9	0.13	1.47	NS
Error	252	0.09		
Blocks x stimuli	10	1.22	3.02	<.01
Blocks x stimuli x groups	10	0.26	0.64	NS
Error	280	0.40		
Blocks x seconds	45	0.07	1.69	<.01
Blocks x seconds x groups	45	0.04	0.94	NS
Error	1260	0.04		
Stimuli x seconds	18	0.26	4.70	<.001
Stimuli x seconds x groups	18	0.02	0.38	NS
Error	504	0.06		
Blocks x stimuli x seconds	90	0.05	2.01	<.001
Blocks x stimuli x seconds x groups	90	0.02	0.86	NS
Error	2520	0.03		

Fig. 5. Mean GSR sec x sec conductance change (collapsed over blocks) to signal sequence for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed

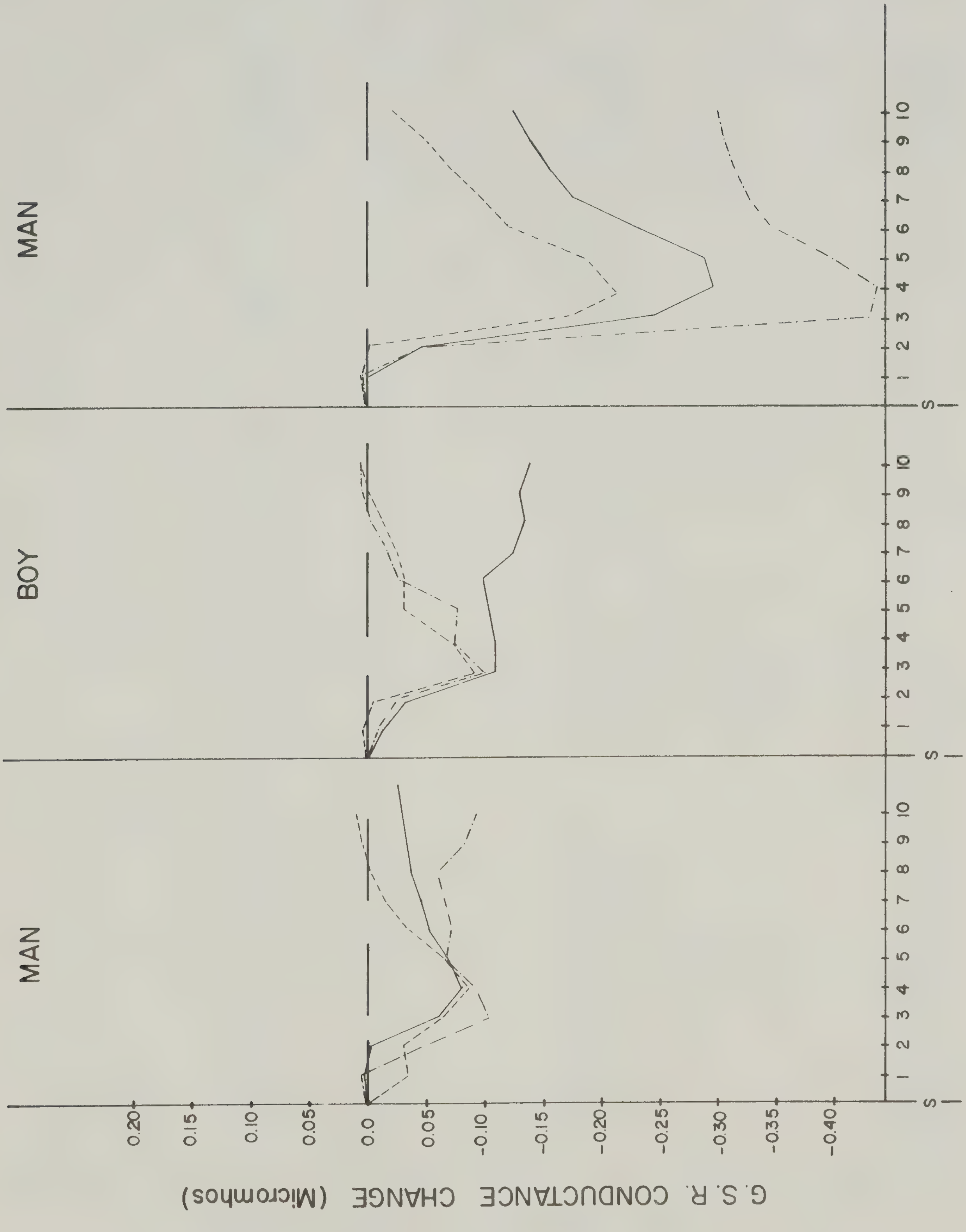
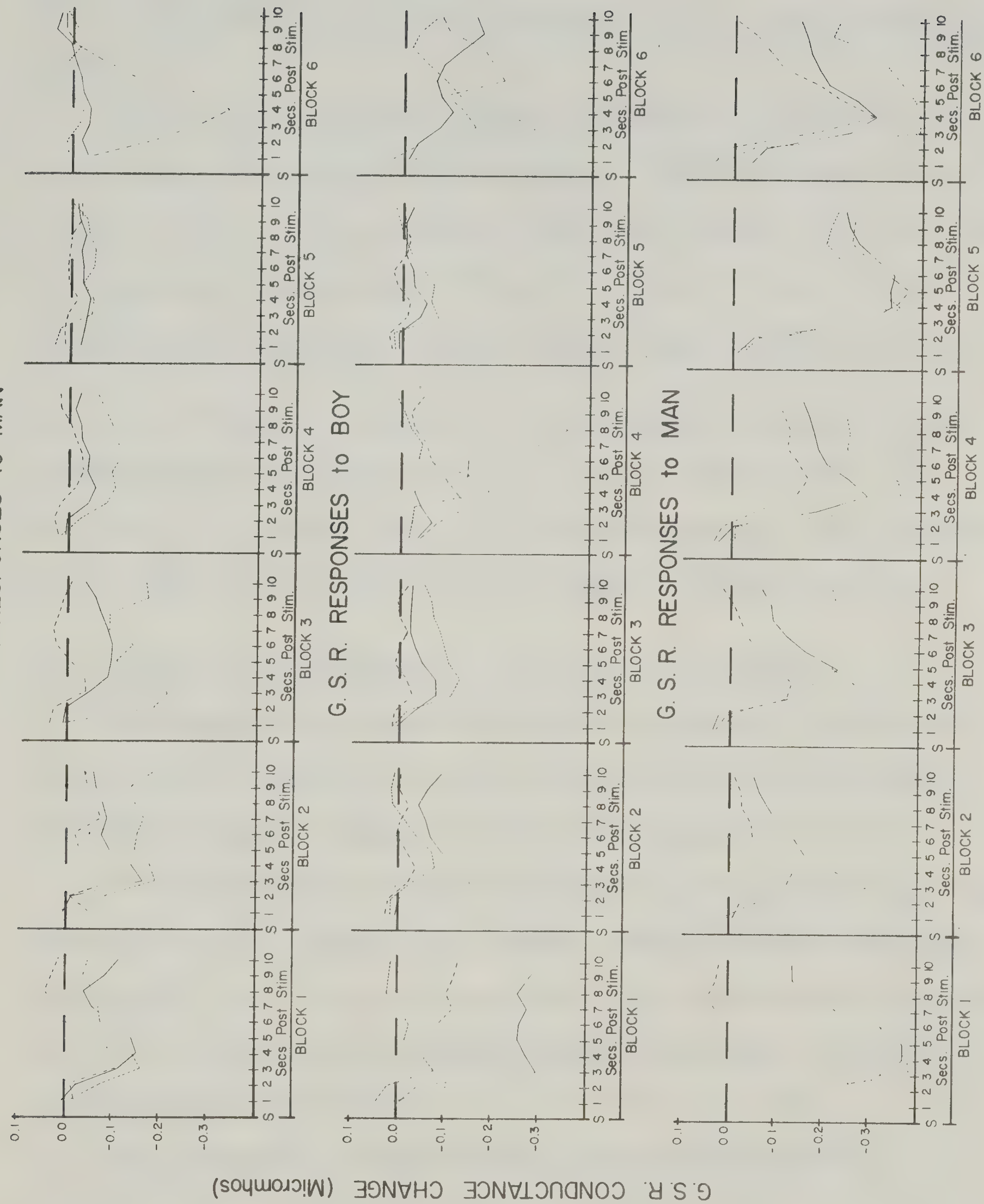

MAN
BOY
MAN
G.S.R. CONDUCTANCE CHANGE (Micromhos)
0.20
0.15
0.10
0.05
0.0
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
S 1 2 3 4 5 6 7 8 9 10
Secs. Postimulus

Fig. 6. Mean GSR sec x sec conductance change over blocks to signal sequence for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


G. S. R. RESPONSES to MAN
G. S. R. RESPONSES to BOY
G. S. R. RESPONSES to MAN
G. S. R. CONDUCTANCE CHANGE (Micromhos)
0.1
0.0
-0.1
-0.2
-0.3
S 1 2 3 4 5 6 7 8 9 10
Secs. Post Stim.
BLOCK 1
BLOCK 2
BLOCK 3
BLOCK 4
BLOCK 5
BLOCK 6

response required in this study was a simple key press which was not effortful. Therefore, one is more likely to attribute the change in GSR to the components in the task (Bernstein *et al.*, 1975; Epstein *et al.*, 1975).

The mean GSR conductance changes (micromhos) for the three stimuli again arranged themselves in order relative to the importance of each (-0.036, -0.063, -0.136 for MAN BOY *MAN*, respectively). The main effect for stimuli was significant ($F = 6.48$, $df = 2/56$, $p < .01$). This follows closely the results in the frequency and magnitude analysis.

The results of this analysis fail to support the prediction that the noninstructed would display a faster rate of habituation of GSR. Some support for the prediction of a greater magnitude of GSR to signals for the normal group as compared to the noninstructed was obtained.

GSR: Analyses of instructed vs. noninstructed treatments

The purposes of the comparisons reported here were to determine if instructions to rehearse the signal sequence would affect the mentally retarded's autonomic responses to the signal sequence.

It was anticipated that the instructions would result in a greater GSR responsiveness to the signal sequence, particularly the imperative signal *MAN*. Also, it was anticipated that the noninstructed group would display a faster rate of decrement (habituation) of GSR as compared to the instructed (Luria, 1963).

The analyses for the instructed vs. noninstructed GSR data

comparisons were identical in format to those carried out for the previous normal vs. noninstructed comparisons.

Frequency. The results of the ANOVA for this dependent variable are given in Table 7. As was found in the previous frequency of GSR analysis, a decrement in response frequency over blocks was evident ($F = 6.10$, $df = 5/140$, $P < .01$). The means for the six blocks (collapsed over stimuli and groups) were 0.72, 0.53, 0.46, 0.40, 0.44, and 0.48. Contrary to expectations, there was no differential rate of decrement of GSR frequency indicated for the two groups. Instructions to rehearse the signal sequence had basically no effect with respect to frequency of responding.

As before, the stimuli gave rise to different levels of GSR frequencies ($F = 6.09$, $df = 5/140$, $P \leq .001$). The imperative signal resulted in a greater frequency of GSR responses. The means (collapsed over blocks and groups) for the MAN BOY MAN signal sequence were 0.42, 0.44 and 0.66, respectively. Group differences were not evident.

Magnitude. The analysis here followed an identical format to the Log_e (x + 1) magnitude analysis for the normal vs. noninstructed comparison. The results of this analysis for the four blocks is given in Table 8.

Again, there was a blocks main effect indicating a rapid decrement in magnitude of response from the first to the second block ($F = 7.87$, $df = 3/84$, $P \leq .001$). The means for the four blocks were 0.27, 0.16, 0.14, and 0.13. There was a somewhat consistent decline in magnitude of response evident which was probably due to the more gradual decline

Table 7

ANOVA for Instructed vs. Noninstructed:
MAN BOY MAN signal sequence; frequency

Source	df	MS	F	P
Between				
Groups	1	0.31	0.29	NS
Error	28	1.10		
Within				
Blocks	5	1.19	6.10	≤.01
Blocks x groups	5	0.42	2.18	
Error	140	0.19		
Stimuli	2	3.05	13.04	≤.001
Stimuli x groups	2	0.46	1.96	NS
Error	56	0.23		
Blocks x stimuli	10	0.17	1.01	NS
Blocks x stimuli x groups	10	0.10	0.62	NS
Error	280	0.16		

Table 8

ANOVA for Instructed vs. Noninstructed:
MAN BOY <u>MAN</u> signal sequence; <u>magnitude</u> in first four blocks

Source	df	MS	F	P
Between				
Groups	1	0.09	0.47	NS
Error	28	0.20		
Within				
Blocks	3	0.37	7.87	≤.001
Blocks x groups	3	0.08	1.76	
Error	84	0.05		
Stimuli	2	0.63	9.71	≤.001
Stimuli x groups	2	0.36	5.49	≤.01
Error	56	0.07		
Blocks x stimuli	6	0.03	0.62	NS
Blocks x stimuli x groups	6	0.04	0.78	NS
Error	168	0.05		

of the magnitude of response for the instructed group. This occurred from blocks one to four (see Figure 3).

The stimuli main effect ($F = 9.71$, $df = 2/56$, $P \leq .001$) again indicated a greater overall magnitude of response for the imperative signal MAN. The means for MAN BOY MAN signal sequence (collapsed over groups and blocks) were 0.14, 0.13 and 0.26, respectively. The noninstructed group also responded with a greater magnitude of response to the imperative signal MAN than the instructed group. There was, however, a stimuli x groups interaction ($F = 5.49$, $df = 2/56$, $P \leq .01$). The instructed group responded similarly to the normals in giving a greater magnitude of response to the imperative signal MAN than did the noninstructed group (see Figure 4). The results for the magnitude of response analysis here followed closely the results obtained for the normal vs. noninstructed comparison.

Second-by-second conductance change. The analysis for the second-by-second conductance change data here followed the same format as the previous second-by-second analysis for the normal vs. noninstructed comparison. Table 9 presents the results of the ANOVA.

The two mentally retarded groups seemed to respond here in a similar fashion as there were no group differences evident. The results followed quite closely those obtained for the previous second-by-second conductance change analysis for normals vs. noninstructed.

Greater magnitude of response was evident for the imperative signal MAN as compared to the other two signals in the sequence. The stimuli main effect was significant ($F = 7.67$, $df = 2/56$, $P \leq .01$). The means (collapsed over blocks, seconds and groups) for the MAN BOY MAN signal

Table 9

ANOVA for Instructed vs. Noninstructed:
MAN BOY <u>MAN</u> signal sequence; <u>sec x sec</u> GSR

Source	df	MS	F	P
Between				
Groups	1	9.08	3.04	NS
Error	28	2.98		
Within				
Blocks	5	0.56	0.73	NS
Blocks x groups	5	0.54	0.71	NS
Error	140	0.76		
Stimuli	2	13.99	7.67	<.01
Stimuli x groups	2	4.12	2.26	NS
Error	56	1.82		
Seconds	9	1.60	12.10	≤.001
Seconds x groups	9	0.19	1.41	NS
Error	252	0.13		
Blocks x stimuli	10	0.62	0.69	NS
Blocks x stimuli x groups	10	1.26	1.40	NS
Error	280	0.90		
Blocks x seconds	45	0.06	1.12	NS
Blocks x seconds x groups	45	0.04	0.83	NS
Error	1260	0.05		
Stimuli x seconds	18	0.44	5.16	<.001
Stimuli x seconds x groups	18	0.12	1.44	NS
Error	504	0.08		
Blocks x stimuli x seconds	90	0.04	0.96	NS
Blocks x stimuli x seconds x groups	90	0.04	0.96	NS
Error	2520	0.04		

sequence were -0.048, -0.033, -0.193, respectively. The stimuli x seconds interaction was also significant ($F = 5.16$, $df = 18/504$, $P \leq .001$). The seconds main effect ($F = 12.10$, $df = 9/252$, $P \leq .001$) verifies that changes from prestimulus level were significant.

Discussion of GSR results. Comparisons between normals and noninstructed. The results of the GSR analyses revealed differences between the normal and noninstructed groups with respect to a decrease in GSR responding. The magnitude measure did indicate a differential decrease as the noninstructed group showed a decrement in magnitude of response from the first to the second block to a greater extent than did the normals. They then maintained this low level of responding with some increase for the remainder of the task. Frequency of response, however, did not differentiate the two groups with respect to habituation over blocks. Both groups displayed a decrease in response frequency over the task.

This points out quite clearly the disparity between different measures of GSR. When one obtains a frequency measure only, considerable loss of information could occur as a conductance change of 500 ohms and 700 ohms are both given a value of one. Lack of any differences in the responses to stimuli may be noted with a frequency when differences do exist in terms of magnitude or amplitude of GSR.

Thus, in the frequency of response analysis reported earlier there was indication of gradual decrement in responding over the six blocks, where the magnitude measure indicated a large decrement from the first to the second block for the noninstructed group and smaller decrement or none at all over the task for the normals (see Figure 3).

The results here fail to support findings of faster rate of habituation in the mentally retarded (cf. Karrer, 1966) when a frequency of GSR measure is employed. However, there is indication that the magnitude of response habituated much faster for the mentally retarded group.

As expected, there was some indication of differential rates of habituation for the three stimuli. The stimuli with greatest signal meaning displayed little or no habituation of GSR over the task in the second-by-second analysis.

Although the mentally retarded missed the key pressing more often than the normals, this did not have an effect on the GSR in any of the analyses for the three measures. The results here, therefore, agree with those of Epstein, Bodreau and Kline (1975) and Bernstein, Taylor and Weinstein (1975) in that the GSR does not seem to be an artifact of the motor response itself.

The above findings of frequency of GSR decrement for the signal sequence follow those predicted by Mackworth (1969) and obtained by others (cf. Das & Bowers, 1970; Coles, Gale & Kline, 1971).

In summary, the only substantial differences of GSR in this study between normals and noninstructed was a difference in magnitude of response to the imperative signal MAN (the normals indicating a greater magnitude of GSR). The only indication of habituation differences was a greater decrement from the first to the second block in magnitude of response for the noninstructed as compared to the normal group.

Effect of instructions. The expectation of a faster rate of habituation of the GSR for the noninstructed was not borne out by the

results. There is some indication in Figure 3 that this might be the case for the magnitude measure, particularly over the first four blocks. However, this did not reach significance in the magnitude analysis. Both groups displayed a decrement in the frequency of GSR to the signal sequence.

Differential levels of responding to the three signals in the sequence MAN BOY MAN were evident for both groups. The magnitude of GSR tended to follow an order similar to the relative importance (or amount of signal meaning) the stimuli held. The instructed group responded with a greater magnitude of GSR to the imperative signal MAN as compared to the noninstructed group. The instructions appear to have focused the "attention" of the instructed group more explicitly on the critical signal in the sequence.

There was some support here for the suggestion by Luria (1961) that there may be some dissociation of the two signaling systems in the mentally retarded. The noninstructed group did display a greater magnitude of GSR response to the imperative signal MAN as opposed to the two signals MAN and BOY, but failed to press for this sequence to a significant degree. The instructed, however, did not make as many errors of omission. The association between the signal sequence MAN BOY MAN and PRESS, therefore, increased the performance in the mentally retarded group. The instructions may have reduced the presumed deficit in verbal regulation of motor behavior (Luria, 1961).

In summary, the only difference found with respect to the two groups was in the magnitude of the GSR to the imperative signal MAN,

the instructed group responding with a greater magnitude of GSR. No significant differences in rate of habituation were found between the two groups or between stimuli. The following section which deals with specific nonsignal sequences and signal vs. nonsignal comparisons may more clearly determine the effect of instructions.

These analyses were carried out to examine Hypothesis 2.4 which predicted that the instructed mentally retarded would display less responsiveness of GSR to nonsignals as compared to the noninstructed.

Responses to nonsignals

This section will examine more closely the GSR responses to some specific nonsignal sequences and some critical signal vs. nonsignal comparisons. The results of analysis for both normal vs. noninstructed and instructed vs. noninstructed will be given together.

The interest here lies in GSRs to different signals placed in different positions in a sequence. The nonsignal sequences CAT BOY MAN and MAN KEY MAN were of major interest as both sequences had the signal MAN in a position at the end of the sequence. The nonsignal sequence MAN BOY CHAIR was also of some interest as it was anticipated that the stimulus CHAIR replacing the expected imperative signal MAN might produce reasonably large magnitudes of response, more so for the normals and the instructed group.

Analyses were carried out first for each nonsignal sequence to elucidate responses to different signals and nonsignals within the sequence; then specific comparisons were made across the two nonsignal sequences CAT BOY MAN and MAN KEY MAN and the signal sequence MAN BOY

MAN. The responses to the last signal MAN in the nonsignal sequence CAT BOY MAN were compared to the responses to the imperative signal MAN in the signal sequence. The same comparison was then carried out for responses to the last MAN in the nonsignal sequence MAN KEY MAN and the imperative signal MAN in MAN BOY MAN.

To achieve greater clarity, the results of all analyses for the nonsignal sequences are given in Appendix C. The results of analyses for all signal vs. nonsignal comparisons are given in Appendix D. Findings of specific analyses are incorporated into the results section of each particular measure and comparison.

At this point one wants to examine the responses to nonsignal sequences. If the relative importance or amount of signal meaning a stimulus holds in a vigilance task does produce differential intensity of responding (i.e., increasing responsiveness to increasing signal meaning), then responses to the nonsignal sequences CAT BOY MAN and MAN KEY MAN should indicate this. This was indeed the case (see Figures 7 and 8). The responses to the nonsignal sequence CAT BOY MAN were in an order relative to the amount of signal meaning each stimulus held. The trends noted in Figure 7 were supported in the second-by-second analysis as a stimuli main effect was observed ($F = 3.73$, $df = 2/56$, $P \leq .05$), as well as a stimuli x seconds interaction ($F = 1.95$, $df = 18/504$, $P \leq .05$). The stimuli x seconds interaction for the instructed vs. noninstructed comparison was not significant. However, the stimuli x seconds x groups interaction was ($F = 1.76$, $df = 18/504$, $P \leq .05$). The instructed group responded less to both BOY and MAN in

Fig. 7. Mean GSR sec x sec conductance change (collapsed over blocks) to nonsignal sequence CAT BOY MAN for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed

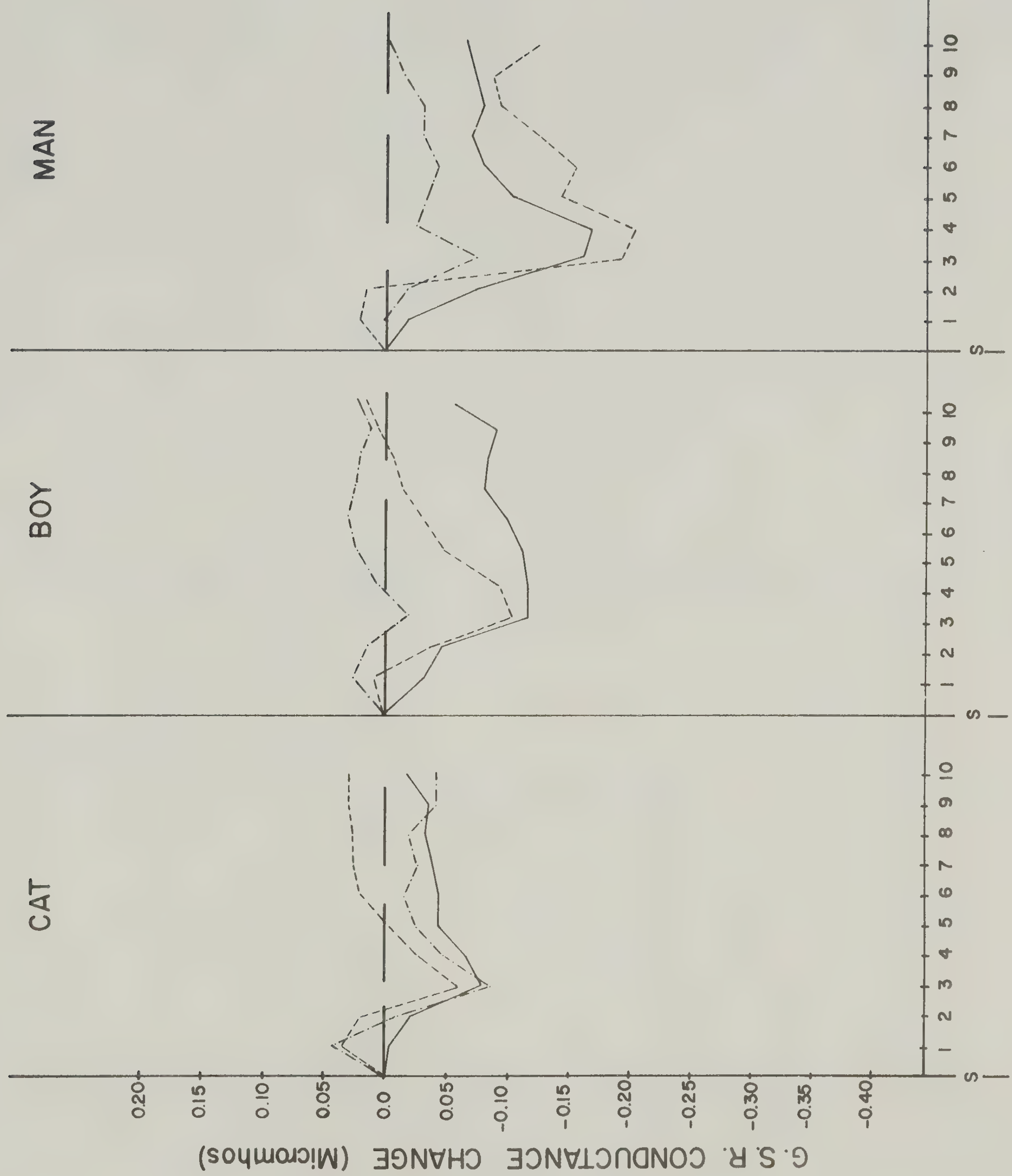
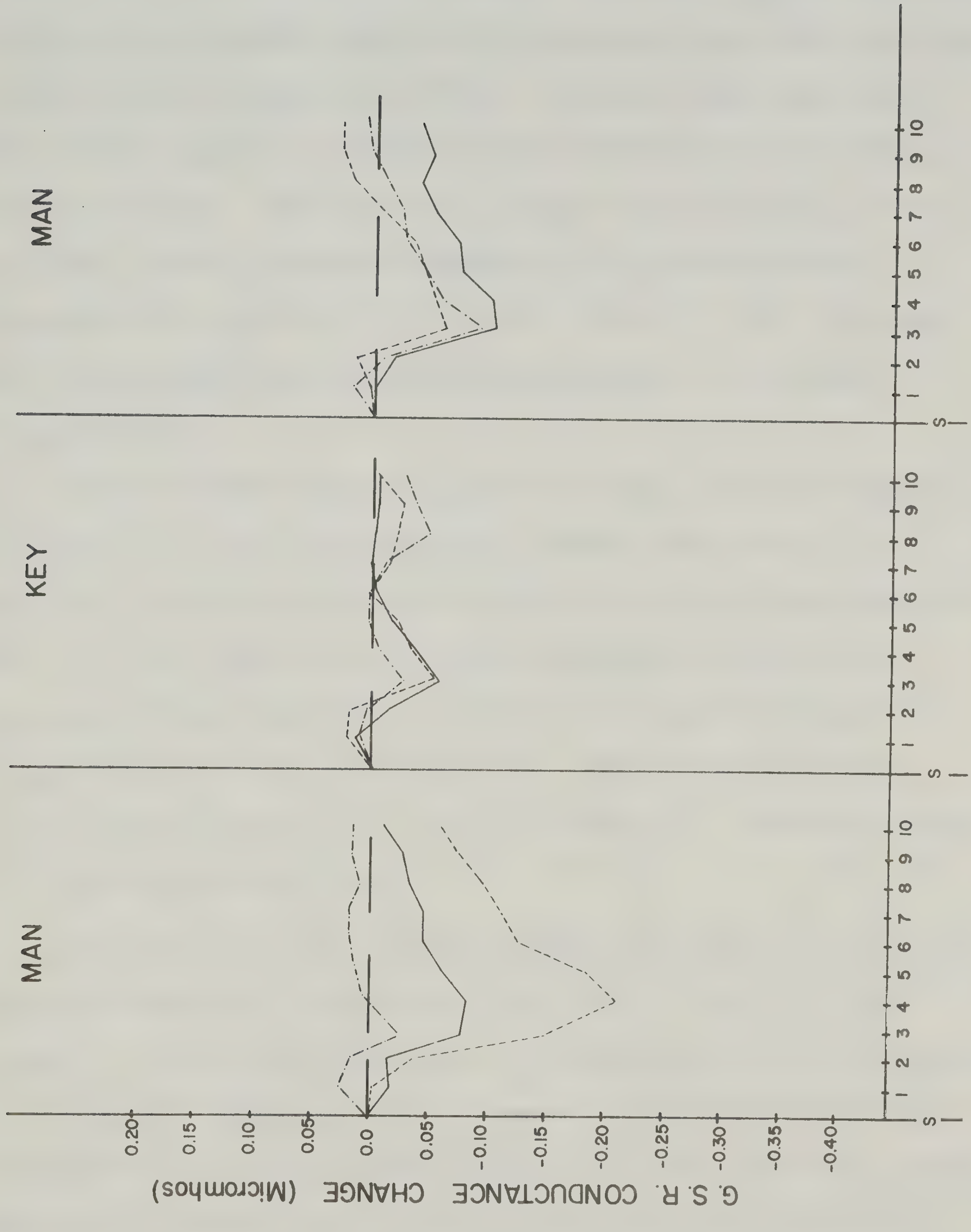

CAT
BOY
MAN
G.S.R. CONDUCTANCE CHANGE (Micromhos)
0.20
0.15
0.10
0.05
0.0
0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
Secs. Postimulus
S 1 2 3 4 5 6 7 8 9 10

Fig. 8. Mean GSR sec x sec conductance change (collapsed over blocks) to nonsignal sequence MAN KEY MAN for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


MAN
KEY
MAN
G. S. R. CONDUCTANCE CHANGE (Micromhos)
0.20
0.15
0.10
0.05
0.0
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
S 1 2 3 4 5 6 7 8 9 10
Secs. Postimulus

the sequence as compared to the noninstructed group and the normals (see Figure 7). The instructions to rehearse the signal sequence appeared to decrease the responsiveness of the instructed group to the two signals in the nonsignal sequence CAT BOY MAN. It appears that they ignored this signal sequence to a greater extent than did the normals and non-instructed group. There was also a greater overall frequency of GSR responses for this nonsignal sequence given by the noninstructed as compared to the instructed ($F = 4.23$, $df = 1/28$, $P \leq .05$). The means for the instructed and noninstructed groups were 0.24 and 0.51, respectively.

The MAN KEY MAN nonsignal sequence also gave rise to differential responding for signals and nonsignals (KEY vs. MAN; see Figure 8). There was greater responsiveness evident for signal words MAN than for KEY. This was supported in the second-by-second analyses, as both analyses yielded significant F-ratios for the stimuli x seconds interactions ($F = 3.34$, $df = 18/504$, $P \leq .001$ for the instructed vs. noninstructed comparison; $F = 1.92$, $df = 18/504$, $P \leq .05$ for the normal vs. noninstructed comparison).

The magnitude of GSR analyses supported the results of the second-by-second conductance change results (for stimuli effects) for the normal vs. noninstructed comparison. A stimulus main effect was observed ($F = 5.17$, $df = 2/56$, $P \leq .01$). The means for the MAN KEY MAN stimuli (collapsed over groups and blocks) were 0.166, 0.104 and 0.113, a greater magnitude of response being evident for the first signal MAN in the sequence. The main effect for stimuli in the analysis of GSR magnitudes

for the instructed vs. noninstructed comparison was not significant. This was probably due to the small magnitude of response to first signal MAN by the noninstructed group (see Figure 8). The frequency analysis also supports the findings in the second-by-second conductance change analysis and magnitude analysis. All three groups responded with greater frequency of GSR to the two signals MAN in the sequence ($F = 9.56$, $df = 2/56$, $P \leq .001$ for normals vs. noninstructed; $F = 8.39$, $df = 2/56$, $P \leq .001$ for instructed vs. noninstructed). The trends noted in Figure 8 with respect to differences in responding to the first MAN in MAN KEY MAN nonsignal sequence between instructed and noninstructed was also supported in the frequency analysis. The stimuli x groups interaction was significant ($F = 5.27$, $df = 2/56$, $P \leq .001$). Figure 9 displays the frequency of response means for the three groups collapsed over blocks for the three stimuli for the MAN KEY MAN nonsignal sequence.

Decrements in GSR for both nonsignal sequences was observed for the frequency measure in all three groups. There was, however, a differential rate of decrement of GSR frequency for the nonsignal sequence MAN KEY MAN between the normal and noninstructed groups (see Figure 10). The normals displayed a gradual decrease in GSR frequency from blocks one to six, whereas the noninstructed displayed a decrease in frequency of GSR from blocks one to three and then increased their responding from blocks four to six. The blocks x groups interaction was significant ($F = 2.63$, $df = 5/140$, $P \leq .025$).

The nonsignal sequence MAN BOY CHAIR gave rise to little differential GSR responding to the stimuli in the sequence, although the normals did tend to respond to the signal BOY with greater intensity than did the

Fig. 9. Mean frequency of GSR (collapsed over blocks) to nonsignal sequence MAN KEY MAN for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed

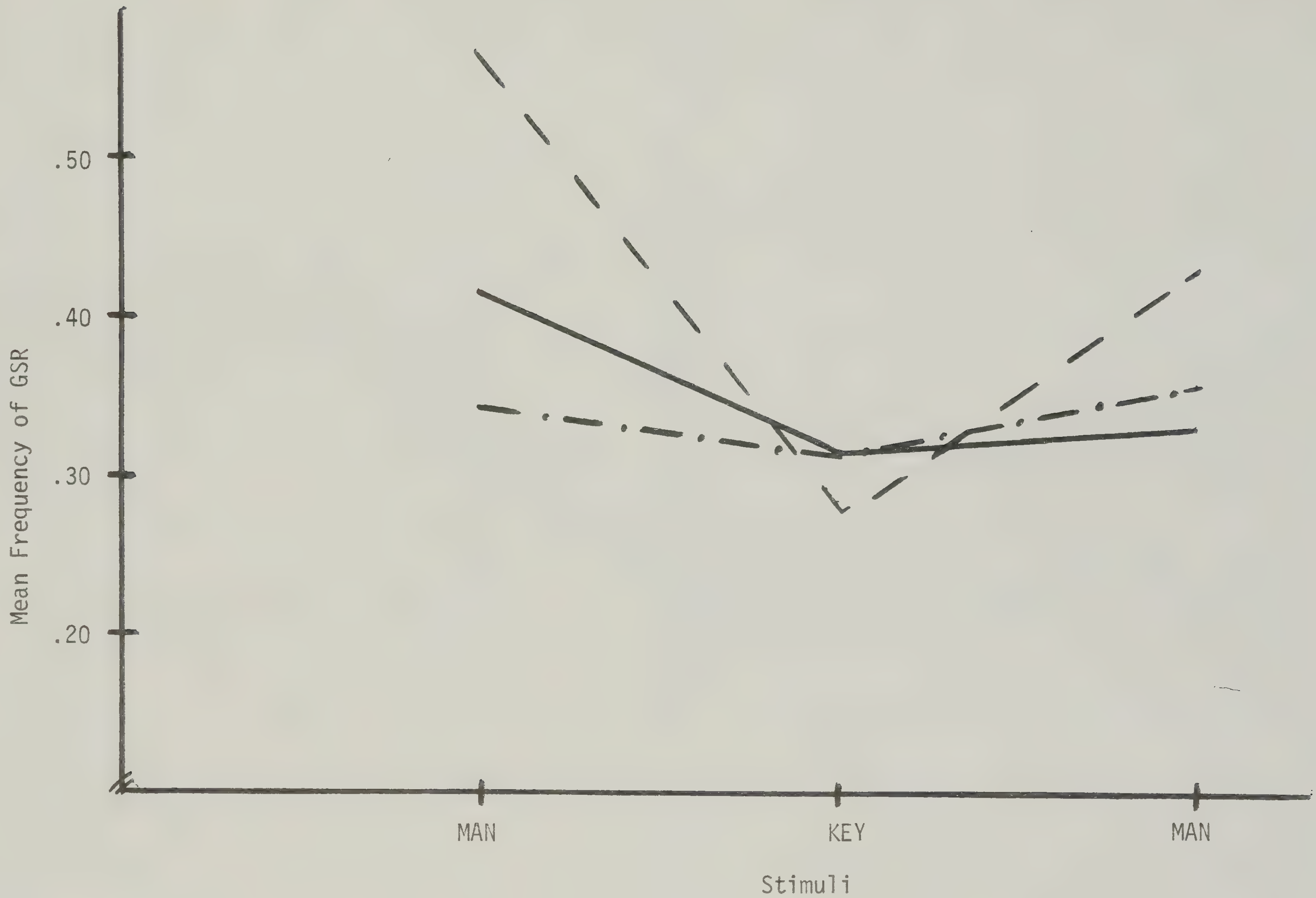
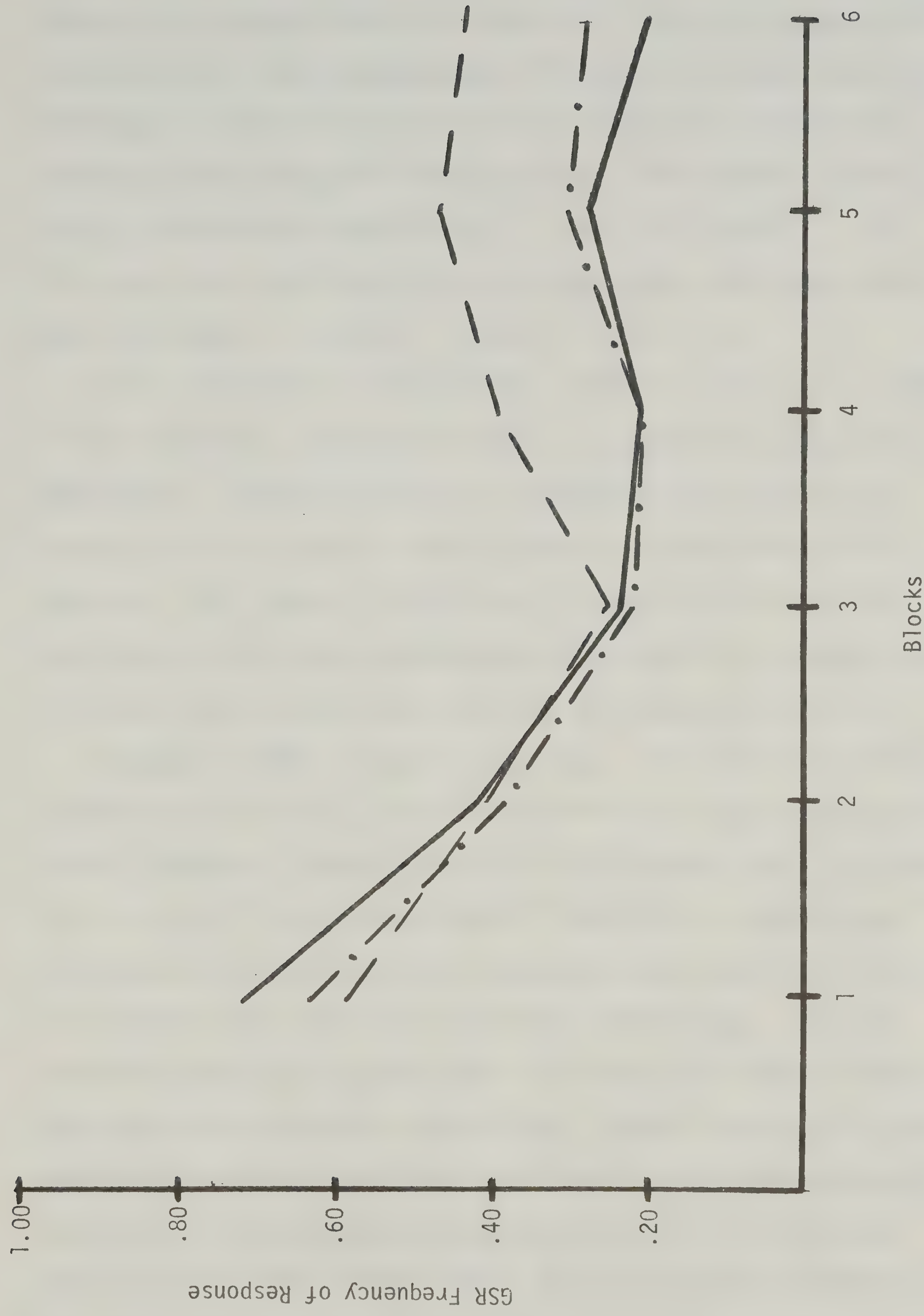

Mean Frequency of GSR
.50
.40
.30
.20
MAN
KEY
MAN
Stimuli

Fig. 10. Mean frequency of GSR (collapsed over stimuli) to nonsignal sequence MAN KEY MAN over blocks for all groups

Normal	————————
Mentally retarded instructed	— . — . —
Mentally retarded noninstructed	— — —


GSR Frequency of Response
1.00
.80
.60
.40
.20
1
2
3
4
5
6
Blocks

two mentally retarded groups (see Figure 11), the least response being displayed by the noninstructed group. The only significant interaction for groups and stimuli was obtained in the normal vs. noninstructed second-by-second conductance change analysis. The stimuli x seconds x groups interaction was significant ($F = 2.16$, $df = 18/504$, $P \leq .01$). The seconds main effect verifies that changes from prestimulus levels were significant ($F = 5.95$, $df = 9/252$, $P \leq .001$).

It is interesting to note that the response to the stimulus CHAIR in the sequence was responded to equally or greater than the signals MAN and BOY. The expectation that the noninstructed would be less responsive to this stimulus than the normals or instructed was not borne out. This response to CHAIR may be indicative of violation of expectancy as the Ss were expecting MAN to be heard, but instead CHAIR was heard; thus a fairly large magnitude of response is indicated.

Responses to MAN: Signal vs. nonsignal. The question of greater responsivity to critical signals than noncritical signals may be more clearly examined by comparing the GSRs of the groups to the signal MAN as it is placed in varying positions of importance or significance. The comparisons here were between the responses to the last signal MAN in CAT BOY MAN to the imperative signal MAN in MAN BOY MAN. The other comparison was obtained between the last signal MAN in MAN KEY MAN and the imperative signal MAN in MAN BOY MAN. Figure 12 displays the GSR responses over seconds (collapsed over blocks) of the three groups to the imperative signal MAN and the two signals MAN in the nonsignal sequence CAT BOY MAN and MAN KEY MAN. The normal group's responses to the three signals again displayed an order or response relative to the

Fig. 11. Mean GSR sec x sec conductance change (collapsed over blocks) for nonsignal sequence MAN BOY CHAIR for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed

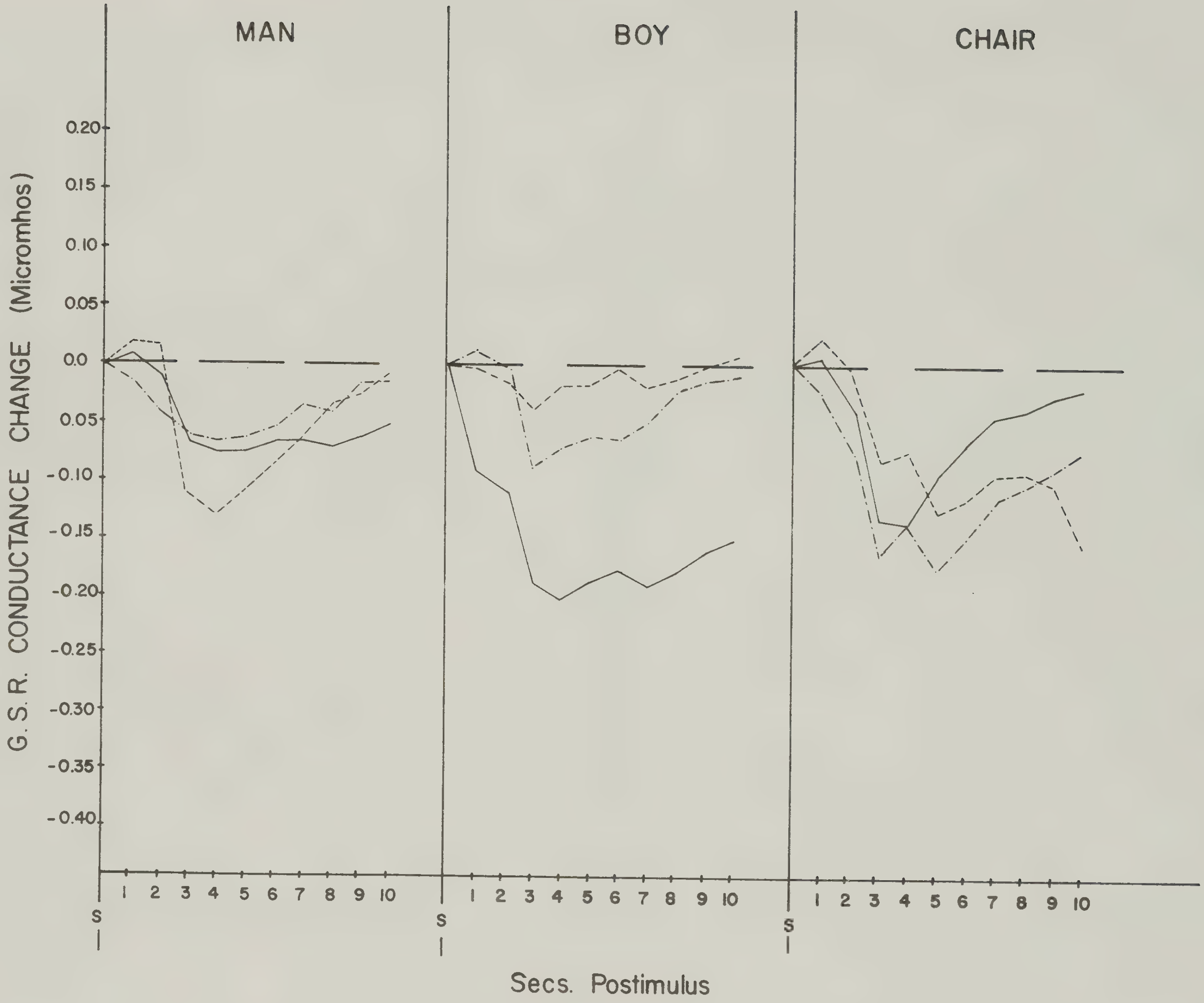
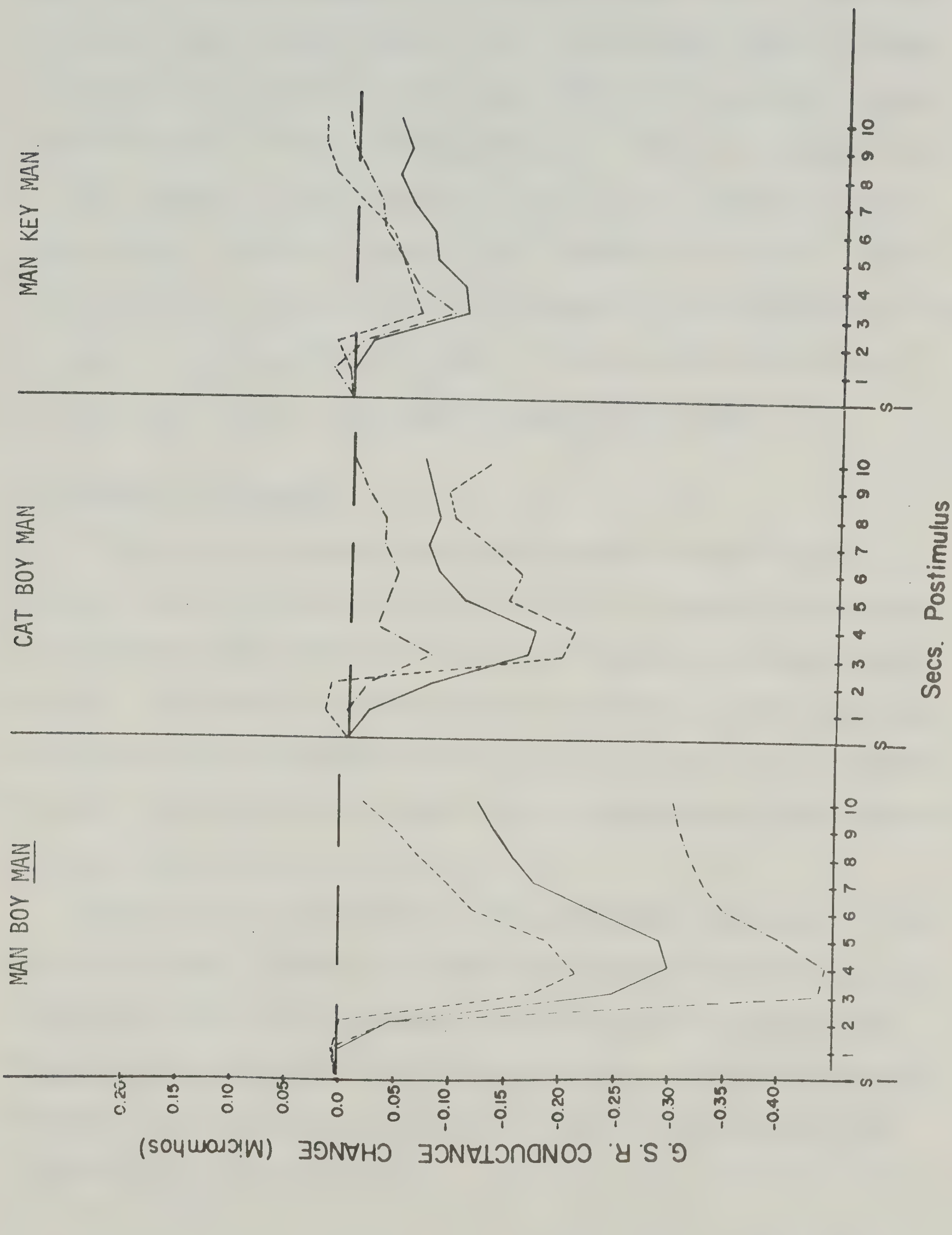

MAN
BOY
CHAIR
G.S.R. CONDUCTANCE CHANGE (Micromhos)
0.20
0.15
0.10
0.05
0.0
0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
S 1 2 3 4 5 6 7 8 9 10
Secs. Postimulus

Fig. 12. Mean GSR sec x sec conductance change (collapsed over blocks) to imperative signal MAN and last MAN in nonsignal sequences CAT BOY MAN and MAN KEY MAN for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


MAN BOY MAN
CAT BOY MAN
MAN KEY MAN
Secs. Postimulus
G. S. R. CONDUCTANCE CHANGE (Micromhos)
0.20
0.15
0.10
0.05
0.0
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
S 1 2 3 4 5 6 7 8 9 10

amount of signal meaning or significance of the signal. The imperative stimulus MAN gave rise to the largest response, followed by the signal MAN in the nonsignal sequence CAT BOY MAN and then the last signal MAN in the nonsignal sequence MAN KEY MAN. The instructed group displayed considerably less response to the signal MAN in the nonsignal sequence CAT BOY MAN than did the noninstructed group. There is indication here of less response to some noncritical signals by the instructed group. Instructions, therefore, appear to have increased performance in the vigilance task by reducing some of the arousal or attentional properties of some of the nonsignificant signals. This may have allowed the Ss to focus more clearly on the signal sequence MAN BOY MAN.

Discussion of GSR results

Hypothesis 1 predicted that the noninstructed would display a faster rate of decrement of GSR to the signal sequence when compared to the normal group. This did receive some support in the magnitude analyses. The noninstructed group did show decrease in GSR magnitude from the first to the second block to a greater extent than the normals. However, they then maintained this level of response, with some increase from the second to the sixth block.

Hypothesis 2.1 predicted that the noninstructed group would display faster decrement in GSR to the signal sequence as compared to the instructed group. This obtained virtually no support in the study. There was some indication that differential rates of magnitude of GSR decrease was in effect (see Figure 3). However, this did not reach significance in the analyses.

A number of studies reviewed earlier had indicated that frequency of GSR responding to stimuli by the mentally retarded is less than that of normals (Lobb, 1970; Karrer & Clausen, 1966). This study does not support these findings. Other studies have also failed to obtain GSR frequency differences (Clausen & Karrer, 1968; Tizard, 1968).

The main differences found with respect to the GSR to stimuli for the groups was in the responses to the imperative signal MAN. The normal and instructed groups responded with a greater magnitude of GSR to this signal as compared to the noninstructed group. Hypothesis 2.2 predicted that the normal group would display a greater magnitude of GSR to the signal sequence as compared to the noninstructed group. This prediction received some support in the study. Also in Hypothesis 2.3 it was predicted that the instructed group would display a greater magnitude of GSR to the signal sequence than the noninstructed. This was the case for the imperative signal MAN.

All three groups displayed a tendency to give a greater magnitude of GSR as the significance of signals increased. The results here reinforce the findings of Bernstein *et al*. (1975).

The effect of instructions on the GSRs of the mentally retarded resulted in a decrease in response to some less significant signals. The responses to the signals BOY and MAN in the nonsignal sequence CAT BOY MAN did not elicit GSRs as readily in the instructed group as it did for the noninstructed group. Also, the noninstructed displayed greater response to the first MAN in the nonsignal sequence MAN KEY MAN as compared to the instructed. Hypothesis 2.4 which stated that the instructed group would display less response of GSR to nonsignals than the noninstructed group therefore received some support in the study.

Heart Rate Results

The following analyses of heart rate data were carried out to examine Hypothesis 3 which predicted that the noninstructed would display faster heart rate habituation to the signals than the normals; also Hypothesis 3.2 which predicted that the normal group would display greater deceleration of heart rate to the signals as compared to the noninstructed.

The statistical procedure followed in the heart rate analyses was identical to that used in the GSR analysis. The second-by-second beats per minute (BPM) change, % deceleration and % acceleration were subjected to an analysis of variance. The results of the signal sequence MAN BOY MAN analyses for the normal vs. noninstructed comparisons will be given first. followed by the results of the instructed vs. noninstructed comparisons. The final section of heart rate results will deal with responses to nonsignal sequences and specific comparisons between the imperative signal MAN and some less significant stimuli as was carried out in the GSR analyses.

Normal vs. noninstructed comparisons

Second-by-second BPM change. The second-by-second beats per minute difference scores were subjected to a 2 (groups) x 6 (blocks) x 3 (stimuli) x 10 (seconds) ANOVA with the last three factors repeated.

Table 10 presents the results of the analysis. Figure 13 presents the mean beats per minute change collapsed over the six blocks for the three stimuli and the three groups.

There was no indication of habituation of the heart rate response to the signal sequence MAN BOY MAN. The blocks main effect ($F = 2.55$, $df = 5/140$, $P \leq .05$) is very difficult to interpret. The means for blocks one to six were -0.36, 0.37, -0.47, 1.21, 0.44, and 0.88, respectively (collapsed over groups and stimuli). There is indication of initial overall deceleration of heart rate from the first to the third block, followed by a fairly strong overall acceleration on the fourth and then some decrease of acceleration of heart rate to the sixth block.

There was indication of differential group heart rate change over the sixth block as well ($F = 2.81$, $df = 5/140$, $P \leq .05$). Figure 14 displays the mean heart rate change (collapsed over stimuli and seconds) for the signal sequence and the three groups. The major difference in responses of the two groups was evident for block three. The mentally retarded responded with an overall large deceleration of heart rate, whereas the normals' response was generally that of heart rate acceleration. The mentally retarded appeared much more inconsistent in terms of heart rate responses as compared to the normals. It is interesting to note that on the third block the greatest number of both errors of omission and false detections were made by the noninstructed group. The seconds main effect ($F = 3.14$, $df = 9/252$, $P \leq .01$) verifies that changes from prestimulus levels were reliable.

Table 10

ANOVA for Normal vs. Noninstructed:
MAN BOY MAN signal sequence; sec x sec BPM change

Source	df	MS	F	P
Between				
Groups	1	295.87	1.06	NS
Error	28	278.35		
Within				
Blocks	5	522.36	2.55	≤.05
Blocks x groups	5	574.78	2.81	≤.05
Error	140	204.70		
Stimuli	2	149.29	0.63	NS
Stimuli x groups	2	233.28	0.99	NS
Error	56	235.72		
Seconds	9	81.61	3.14	≤.01
Seconds x groups	9	25.12	0.97	NS
Error	252	26.00		
Blocks x stimuli	10	179.95	0.82	NS
Blocks x stimuli x groups	10	306.47	1.40	NS
Error	280	219.34		
Blocks x seconds	45	9.44	0.88	NS
Blocks x seconds x groups	45	6.77	0.63	NS
Error	1260	10.74		
Stimuli x seconds	18	18.82	1.43	NS
Stimuli x seconds x groups	18	13.55	1.01	NS
Error	504	13.39		
Blocks x stimuli x seconds	90	9.21	0.69	NS
Blocks x stimuli x seconds x groups	90	20.58	1.54	NS
Error	2520	13.37		

Fig. 13. Mean heart rate sec x sec BPM change (collapsed over blocks) to signal sequence for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed

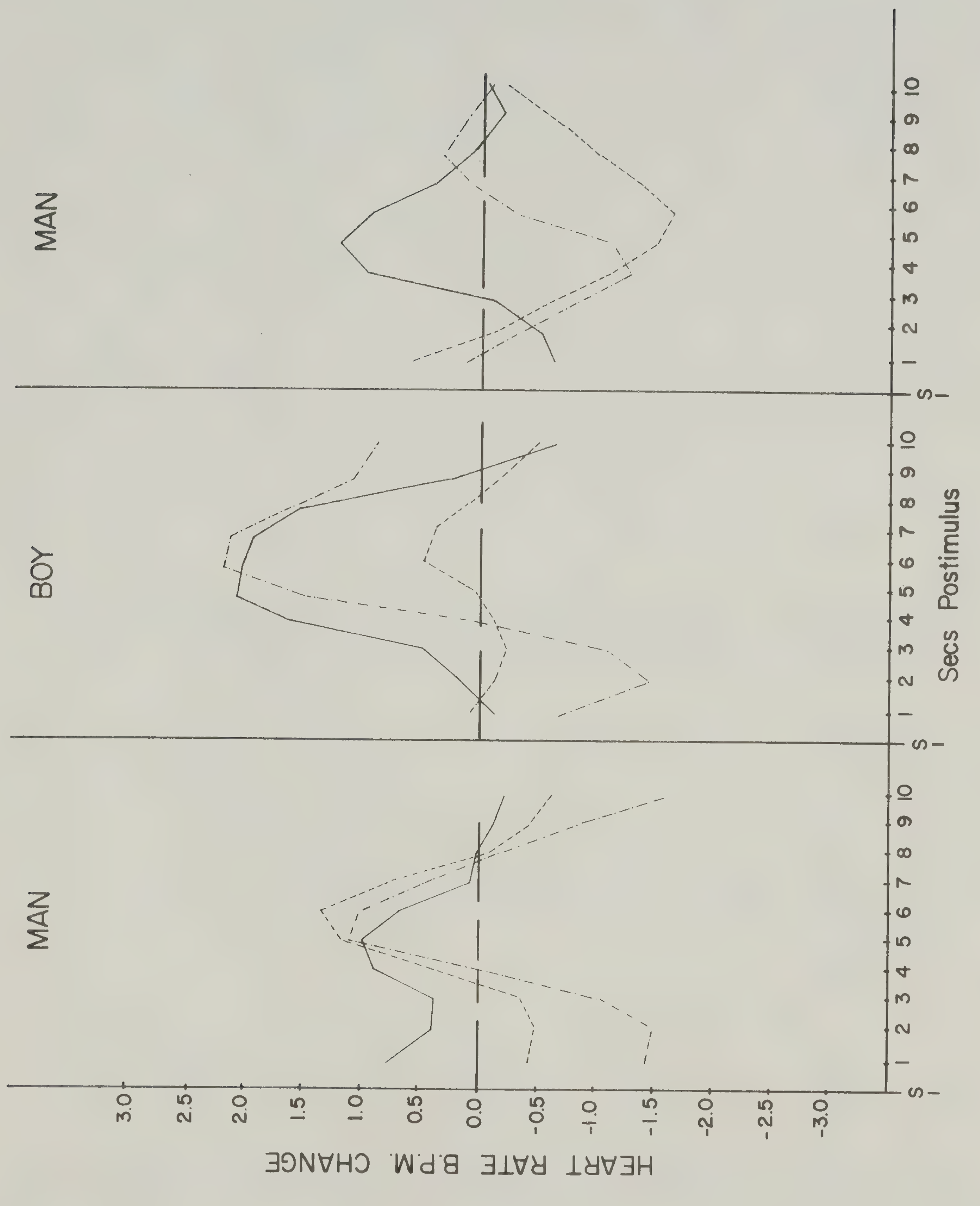
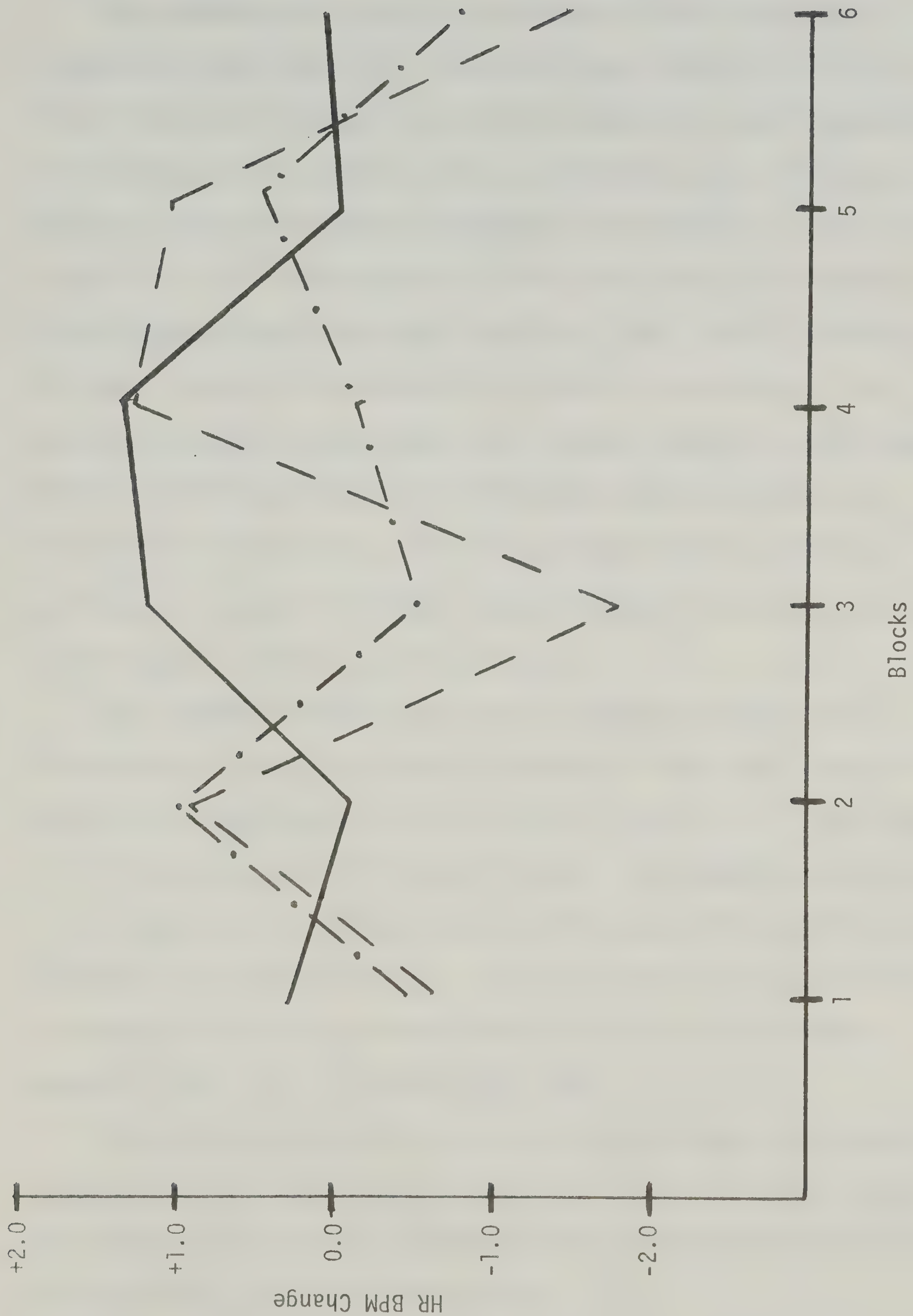

MAN
BOY
MAN
HEART RATE B.P.M. CHANGE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
S 1 2 3 4 5 6 7 8 9 10
S 1 2 3 4 5 6 7 8 9 10
S 1 2 3 4 5 6 7 8 9 10
Secs Postimulus

Fig. 14. Mean heart rate BPM change (collapsed over stimuli and seconds) over blocks to signal sequence for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


HR BPM Change
+2.0
+1.0
0.0
-1.0
-2.0
1
2
3
4
5
6
Blocks

The responses over seconds to the three signals were quite interesting (see Figure 13), the normal group displaying a fairly large acceleration of heart rate for the imperative signal MAN and BOY in the sequence as compared to the noninstructed group. The stimuli x seconds x groups interaction approached significance ($F = 1.43$, $df = 18/504$, $P \leq .10$). The responses of the normal group to the imperative signal MAN appeared to indicate attention to this signal, followed by the motor response of pressing the key (heart acceleration). The mentally retarded, on the other hand, attended primarily to the signal (heart rate deceleration), the acceleration component being less pronounced for this group. This also followed from the vigilance performance data which indicated a greater number of omissions for the signal sequence by the noninstructed group.

The responses of acceleration to BOY, however, could not be interpreted as a result of a motor response for the normal group, as they did not press the key for this signal. Rather, it is likely due to the importance that this signal played in the sequence and may reflect covert rehearsal of the signal or some related cognitive activity which maintains the signal in memory. Active cognitive activity has been demonstrated to produce cardiac acceleration (Lacey, 1967; Tursky, Swartz & Crider, 1971; Pribram et al., 1975).

The noninstructed group, on the other hand, seemed to respond in terms of just an "attentional" component or not at all to the signal BOY. They did not display the fairly large acceleration of heart rate that was observed for the normal group.

Per cent deceleration. The % deceleration of heart rate data were subjected to a 2 (groups) x 6 (blocks) x 3 (stimuli) ANOVA with the last two factors repeated. There were no significant differences between groups with respect to stimuli, although there was more deceleration of heart rate to the imperative signal MAN. The means collapsed over groups and stimuli were 2.85, 2.42 and 3.47 for the MAN BOY MAN signals, respectively. However, this did not reach significance in the ANOVA ($F = 1.32$, $df = 2/56$, $P \leq .25$).

Per cent acceleration. The % acceleration analysis followed the identical format to that for the % deceleration dependent variable. The only significant result observed was the main effect for groups ($F = 4.56$, $df = 1/28$, $P \leq .05$). The normal group displayed a greater overall degree of acceleration than for the noninstructed. The means collapsed over blocks and stimuli for the normal and noninstructed groups were 5.07 and 3.35, respectively. The difference appeared to be affected by the large amount of acceleration for the first two signals in the sequence for the normal as evidenced in Figure 13. The means for % acceleration for the three signals in the sequence collapsed over blocks are given in Table 11 for the two groups.

Table 11

Mean % Acceleration of Heart Rate for MAN BOY MAN

	Stimuli		
Group	MAN	BOY	MAN
Normal	5.45	5.97	3.79
Noninstructed	3.86	3.51	2.67

The blocks main effect ($F = 2.45$, $df = 5/40$, $P \leq .05$) indicated increased overall % acceleration of heart rate to the fourth block, then decreasing over the fifth and sixth blocks. The means for blocks one to six were 2.5, 4.7, 4.04, 6.19, 4.68, and 3.13. This may be indicative of increasing cognitive effort required to maintain the signals in memory from the first to the fourth block. There was no significant indication of a decrement in % acceleration of heart rate occurring over the task.

Heart rate: Analysis of instructed vs. noninstructed treatments

The following analyses of heart rate data for these two groups were carried out to examine Hypothesis 3.1 which predicted that the instructed group would display a slower rate of heart rate habituation to the signals as compared to the noninstructed; also Hypothesis 3.3 which predicted that the instructed mentally retarded would display greater deceleration of heart rate to the signals than the noninstructed was tested here.

Second-by-second BPM change. The second-by-second beats per minute change data analysis for the instructed vs. noninstructed followed the identical format to that for the previous normal vs. noninstructed comparisons. The results of the analysis for this measure are given in Table 12.

As was observed in the previous analysis, a block main effect was obtained ($F = 4.48$, $df = 5/140$, $P \leq .001$). The means (collapsed over groups, stimuli and seconds) for blocks one to six were: -0.59, 0.84, -1.28, 0.59, 0.84, and -1.20. The effect here appears to be due to the large overall deceleration noted for the third and sixth blocks. Why this occurred is not clear as there is no indication of a general

Table 12

ANOVA for Instructed vs. Noninstructed:
MAN BOY MAN signal sequence; sec x sec BPM change

Source	df	MS	F	P
Between				
Groups	1	12.91	0.07	NS
Error	28	194.78		
Within				
Blocks	5	911.16	4.48	≤.01
Blocks x groups	5	202.44	1.00	NS
Error	140	203.38		
Stimuli	2	494.52	2.94	NS
Stimuli x groups	2	263.53	1.56	NS
Error	56	168.49		
Seconds	9	135.54	6.07	≤.001
Seconds x groups	9	50.64	2.27	≤.05
Error	252	22.34		
Blocks x stimuli	10	313.95	1.67	NS
Blocks x stimuli x groups	10	401.19	2.13	NS
Error	280	188.50		
Blocks x seconds	45	8.08	0.83	NS
Blocks x seconds x groups	45	8.83	0.91	NS
Error	1260	9.72		
Stimuli x seconds	18	57.21	4.49	≤.001
Stimuli x seconds x groups	18	9.89	0.78	NS
Error	504	12.73		
Blocks x stimuli x seconds	90	16.79	1.49	NS
Blocks x stimuli x seconds x groups	90	15.28	1.35	NS
Error	2520	11.29		

decrement or increment in heart rate changes.

There were differential patterns of heart rate responses to the three signals ($F = 4.49$, $df = 18/504$, $P \leq .001$). This appeared to be due to the fairly large acceleration of heart rate to the first two signals in the signal sequence, whereas the imperative signal MAN produced generally deceleration. The instructed group displayed responses to BOY and the first MAN in the sequence which was very similar to the responses obtained for the normal group. This may be a result of the overt and/or covert rehearsal of the signal sequence by the instructed, which resulted in a similar heart rate response to the normals. Covert verbalization has been indicated to produce cardiac acceleration (Campos & Johnson, 1968).

Per cent deceleration. Table 13 presents the results of this analysis. As before, a block main effect was observed ($F = 4.04$, $df = 5/140$, $P \leq .001$). The means for blocks one to six (collapsed over groups and stimuli) were: 4.36, 2.40, 4.57, 2.09, 1.85, and 4.31, respectively. The reason for such a pattern of results is not clear; however, it may be related to fluctuations in "attention" occurring over the blocks as in one instance considerable deceleration of heart rate was evident and in another it was not. The ease of the vigilance task may have resulted in the shifting of attention from time to time.

The stimuli main effect ($F = 3.68$, $df = 2/56$, $P \leq .05$) was quite interesting as greater deceleration occurred for the two MAN signals in the signal sequence as compared to the signal BOY. The means (collapsed over blocks and groups) for the MAN BOY MAN signal sequence were: 3.22, 2.55, and

Table 13

ANOVA for Instructed vs. Noninstructed:
MAN BOY MAN signal sequence; HR % deceleration

Source	df	MS	F	P
Between				
Groups	1	0.43	0.01	NS
Error	28	47.33		
Within				
Blocks	5	146.01	4.04	≤.025
Blocks x groups	5	28.16	0.78	NS
Error	140	36.13		
Stimuli	2	97.31	3.68	≤.05
Stimuli x groups	2	12.49	0.47	NS
Error	56	26.41		
Blocks x stimuli	10	31.48	0.92	NS
Blocks x stimuli x groups	10	51.34	1.50	NS
Error	280	34.21		

4.02, respectively. The two mentally retarded groups displayed a greater "attentional" component (as indexed by heart rate deceleration) to the two MAN signals rather than the relatively important signal BOY. The imperative signal MAN did give rise to greater deceleration of heart rate than the other two signals, however. The tendency of the mentally retarded to respond less autonomically to a warning signal than to an imperative signal has been noted previously (Das & Bower, 1971). This could result in a greater number of false detections as they would miss the critical signal BOY in the series. Both groups also displayed more false detections in the vigilance task as compared to the normals.

Per cent acceleration. The results of this analysis yielded one major finding. The block main effect ($F = 3.16$, $df = 5/140$, $P \leq .01$) again suggests a great deal of variation in responding over the six blocks. The means (collapsed over groups and stimuli) were: 2.45, 4.98, 2.50, 4.43, 5.04, and 2.72. The heart rate acceleration changes over blocks again did not display a consistent pattern of decrement. There is no indication here that habituation of this component of heart rate occurred.

There were no group differences or group x stimuli differences with respect to heart rate acceleration to the signal sequence.

The heart rate responses of the three groups to the signal sequence were quite variable over the task, with no real pattern of responses over time evident. This general lack of consistent responding may have been due to the relative ease with which the majority of the Ss performed in the vigilance task. Thus, "attention"

to the signal sequence as measured by heart rate tended to fluctuate throughout the task, as heart rate has been noted to be highly sensitive to task demands (Dahl & Spence, 1974). If the task had been more difficult, one might anticipate more consistent findings of decrement of heart rate responses as the changes in heart rate would likely be more pronounced in the task.

There were no indications here of heart rate response habituation for either of the three groups. The heart rate response of deceleration and acceleration has been found previously to be somewhat inconsistent with respect to habituation (Holloway & Parsons, 1971; Jackson, 1974).

Few differences were apparent among the three groups. The instructed group did tend to follow more closely the normal group with respect to acceleration of heart rate to the signal BOY (see Figure 13).

Heart rate responses in terms of % deceleration, however, did differentiate responses to the signal stimuli in the sequence. The first signal MAN and the imperative signal MAN both gave rise to greater deceleration of heart rate for the two mentally retarded groups than did the signal BOY. The mentally retarded groups, therefore, appeared to pay more attention to the MAN signal than the critical signal BOY in the sequence; whereas the normals responded more similarly to all three signals in the sequence.

Responses to nonsignals. As in the case of GSR, the results of the heart rate analysis for the nonsignal sequences are given in Appendix E. The results of all signal vs. nonsignal comparisons are given in Appendix F. Findings of specific analysis are incorporated into the results section of each particular measure and comparison.

The interest here is in the heart rate responses of the three groups to different signals placed in different positions in a sequence. As for the GSR, the nonsignal sequences CAT BOY MAN and MAN KEY MAN were of major interest as both sequences had the signal MAN in a position at the end of the sequence. The signal sequence MAN BOY CHAIR was also of interest as it was anticipated that the stimulus CHAIR replacing the imperative signal MAN would produce a large acceleration of heart rate as a result of violation of expectancy. The normal and instructed groups were expected to display this to a greater extent than the noninstructed group.

As was the case for the GSR data, analyses were carried out first for each nonsignal sequence to elucidate responses to different signals and nonsignals within the sequence. Specific comparisons were then carried out across the two nonsignal sequences CAT BOY MAN and MAN KEY MAN. The responses to the last MAN in the nonsignal sequence CAT BOY MAN were compared to responses to the imperative signal MAN in MAN BOY MAN. The same comparisons were then carried out for responses to the last MAN in MAN KEY MAN and to the imperative signal MAN in MAN BOY MAN.

Responses to nonsignal sequences. The heart rate second-by-second response data for the nonsignal sequences CAT BOY MAN, MAN KEY MAN and MAN BOY CHAIR were subjected to 2 (groups) x 6 (blocks) x 3 (stimuli) x 10 (seconds) ANOVAs with the last three factors repeated. The mean second-by-second beats per minute change (collapsed over blocks) for the three nonsignal sequences and groups are given in Figures 15, 16 and 17.

Fig. 15. Mean heart rate sec x sec BPM change (collapsed over blocks) to nonsignal sequence CAT BOY MAN for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed

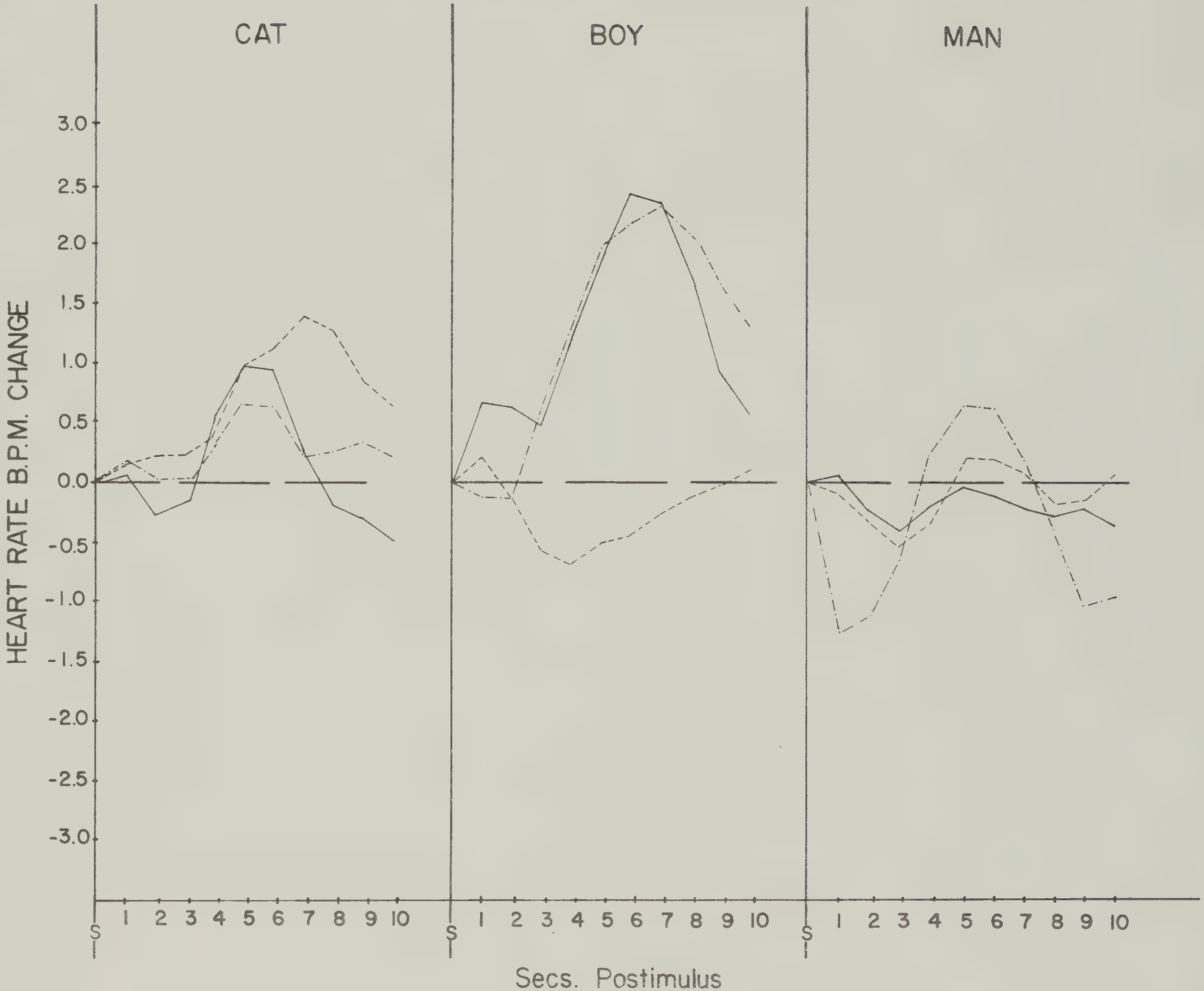

CAT
BOY
MAN
HEART RATE B.P.M. CHANGE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
S 1 2 3 4 5 6 7 8 9 10
Secs. Postimulus

Fig. 16. Mean heart rate sec x sec BPM change (collapsed over blocks) to nonsignal sequence MAN KEY MAN for all groups

Normal ———————

Mentally retarded instructed — • — • —

Mentally retarded noninstructed — — —

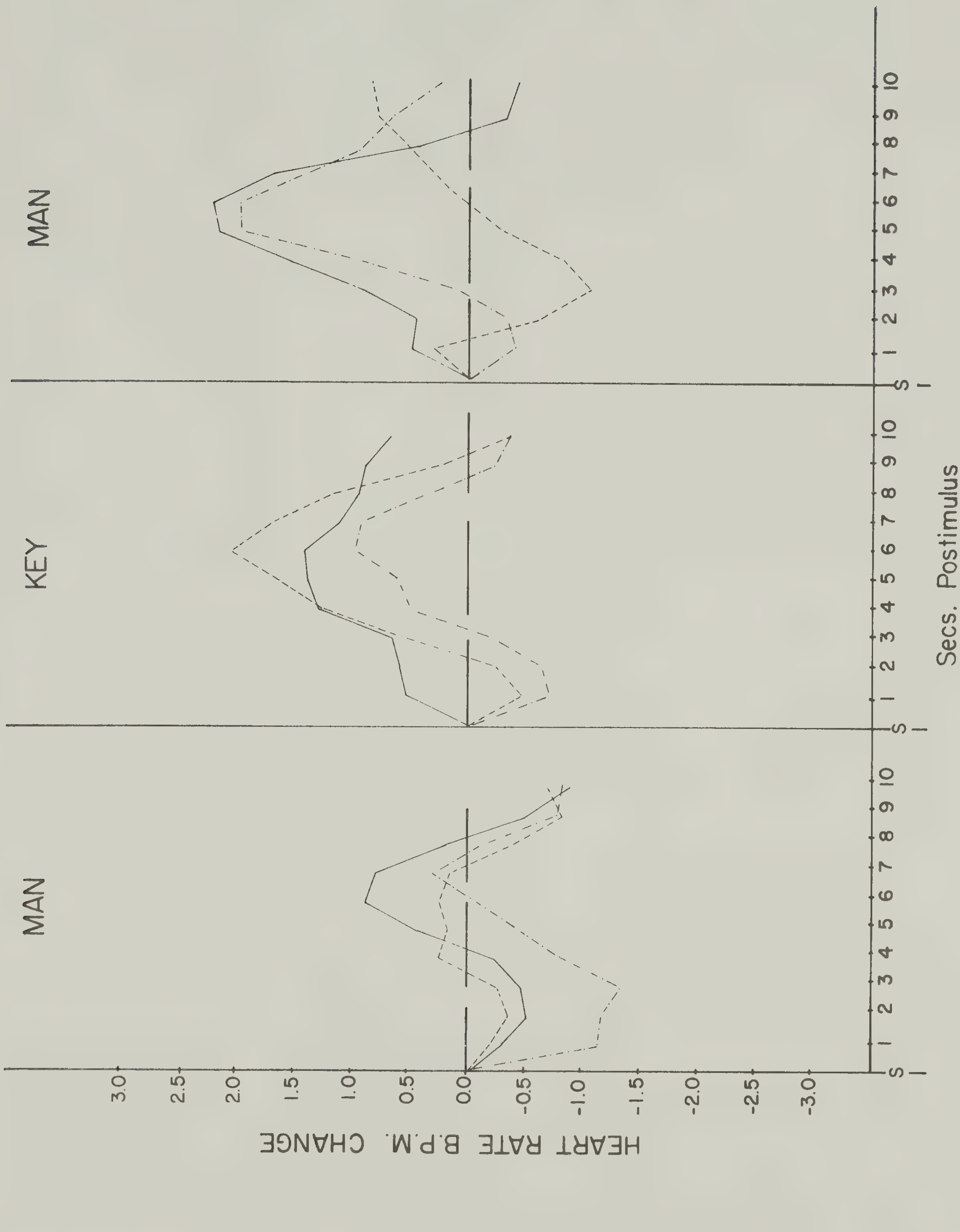
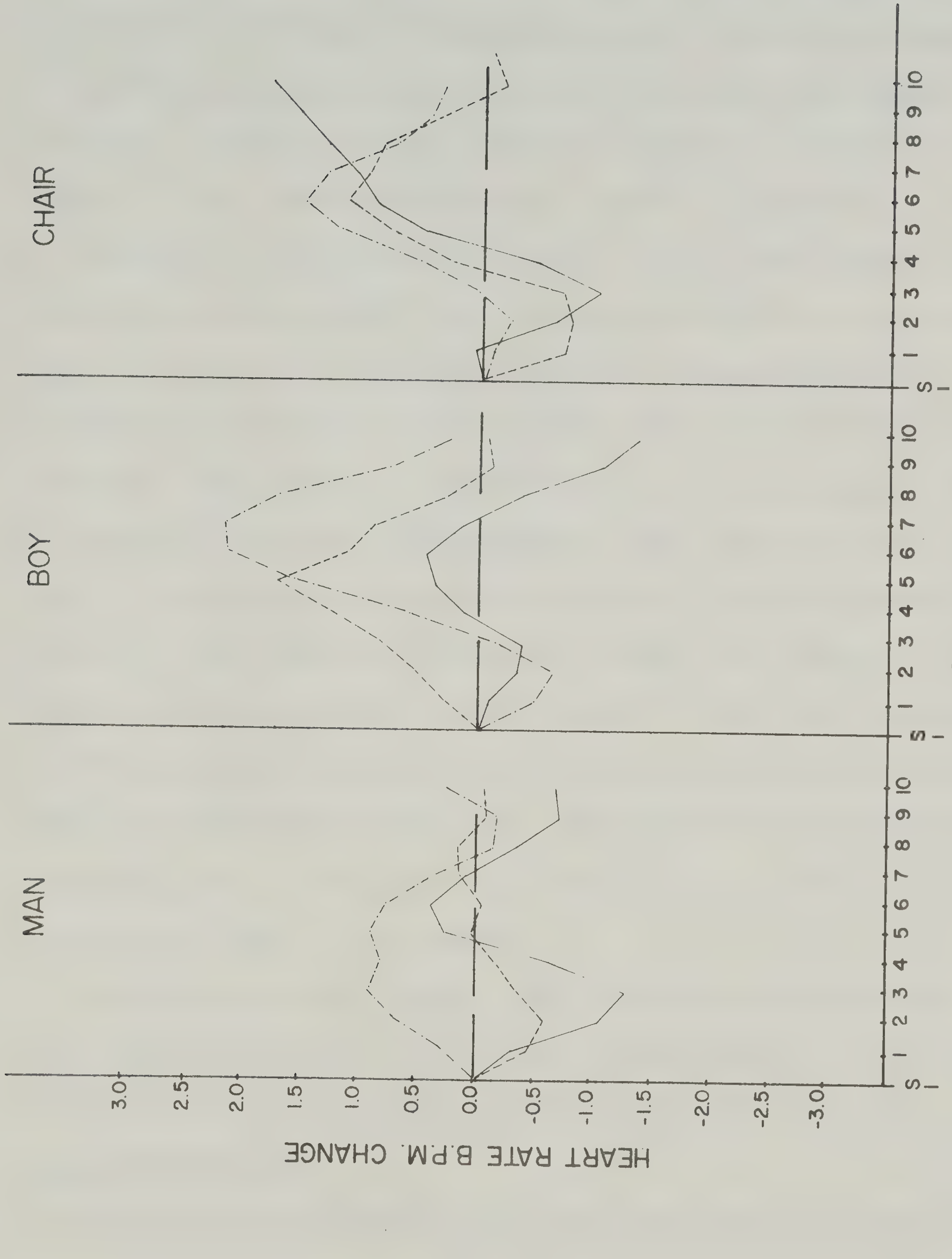

MAN
KEY
MAN
HEART RATE B.P.M. CHANGE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
S 1 2 3 4 5 6 7 8 9 10
Secs. Postimulus

Fig. 17. Mean heart rate sec x sec BPM change (collapsed over blocks) to nonsignal sequence MAN BOY CHAIR for all groups

Normal	————————
Mentally retarded instructed	— · — · —
Mentally retarded noninstructed	— — —


MAN
BOY
CHAIR
HEART RATE B.P.M. CHANGE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
S 1 2 3 4 5 6 7 8 9 10
S 1 2 3 4 5 6 7 8 9 10
S 1 2 3 4 5 6 7 8 9 10
Secs. Postimulus

The major finding of significance for the CAT BOY MAN signal sequence was a difference in the second-by-second heart rate responses of the instructed and noninstructed groups with respect to stimuli. The stimuli x seconds x groups interaction yielded an $F = 1.78$ ($df = 18/504$, $P \leq .05$). Upon examination of Figure 15, it appeared that this was mainly due to the heart rate responses to BOY in the sequence. The instructed group displayed a heart rate response similar to that of the normals as there was a deceleration component followed by a fairly extensive heart rate acceleration response. The noninstructed, on the other hand, displayed only a deceleration of heart rate response. Thus, the normals and instructed group seemed to focus more on this signal in terms of some cognitive or somato-motor activity. The incongruence of having the signal BOY occur immediately following the nonsignal CAT may also be a factor as this was the only instance in which this occurred. The normal and instructed groups may have noted the incongruence, thus resulting in heart rate acceleration. The noninstructed group may not have been as aware of the importance of this signal and thus just have "listened" or "taken in" the stimuli.

It seems more likely, however, that the acceleration is due to covert cognitive activity, as this same response to BOY by the normals and instructed group was evident for the signal BOY in the signal sequence MAN BOY <u>MAN</u>.

The analyses for the MAN KEY MAN signal sequence also yielded some noteworthy findings (see Figure 16). The instructed and normal groups responded differently to the last signal MAN as compared to the non-

instructed group. The groups x stimuli x seconds interaction in the second-by-second BPM analyses for both normal vs. noninstructed and instructed vs. noninstructed was significant ($F = 2.95$, $df = 18/504$, $P \leq .01$ for normals vs. noninstructed; $F = 2.12$, $df = 18/504$, $P \leq .01$ for instructed vs. noninstructed).

Again, as was the case for the signal BOY, the heart rate response to a signal displayed by the noninstructed is almost the reverse of that displayed by the normal and instructed groups. The mentally retarded and normal groups both responded to the last signal MAN in the MAN KEY MAN nonsignal sequence with a fairly large acceleratory component of heart rate. The noninstructed group, however, displayed a fairly strong deceleration of heart rate, then some late acceleration or just return to prestimulus level. The noninstructed also pressed more often for this signal than the instructed or normal groups.

The heart rate responses to the nonsignal sequence MAN BOY CHAIR did give some indication of a "violation of expectancy" effect for the normal group (see Figure 17). They indicated a later acceleratory component of heart rate occurring from the fifth to the tenth second poststimulus, with no indication of a gradual return to prestimulus level at the end of the tenth second. The two mentally retarded groups displayed an initial deceleration of heart rate, followed by acceleration and return to prestimulus level. The effect of violation of expectancy appeared greatest for the normal group. However, the stimulus x seconds x groups and the stimuli x groups interactions were not significant. The observed difference between the normal groups,

therefore, may be due to a greater variance of response within the normal group.

There was, however, differential heart rate response to the stimuli as evidenced in the second-by-second BPM change analyses. The stimuli x seconds interactions ($F = 4.17$, $df = 18/504$, $P \leq .001$ for normals vs. noninstructed; $F = 2.09$, $df = 18/504$, $P \leq .01$ for instructed vs. noninstructed) was significant. It is not immediately clear as to what is happening here (see Figure 17). However, the heart rate responses to the signal BOY and the nonsignal CHAIR did indicate greater degrees of acceleration of heart rate over the seconds as compared to the signal MAN. This was also found in other analyses involving the signal BOY.

The <u>% deceleration</u> analyses for MAN BOY CHAIR indicated differential amounts of heart rate deceleration for the instructed and noninstructed groups (see Figure 18). The stimuli x groups interaction for the two groups was significant ($F = 3.96$, $df = 2/56$, $P \leq .05$). The indication here was that the noninstructed group responded to the first signal MAN in the sequence with <u>greater</u> deceleration of heart rate. They also displayed <u>less</u> deceleration for the signal BOY than the instructed and <u>greater</u> deceleration for CHAIR. The normals, on the other hand, displayed about the same amount of heart rate deceleration for all three stimuli.

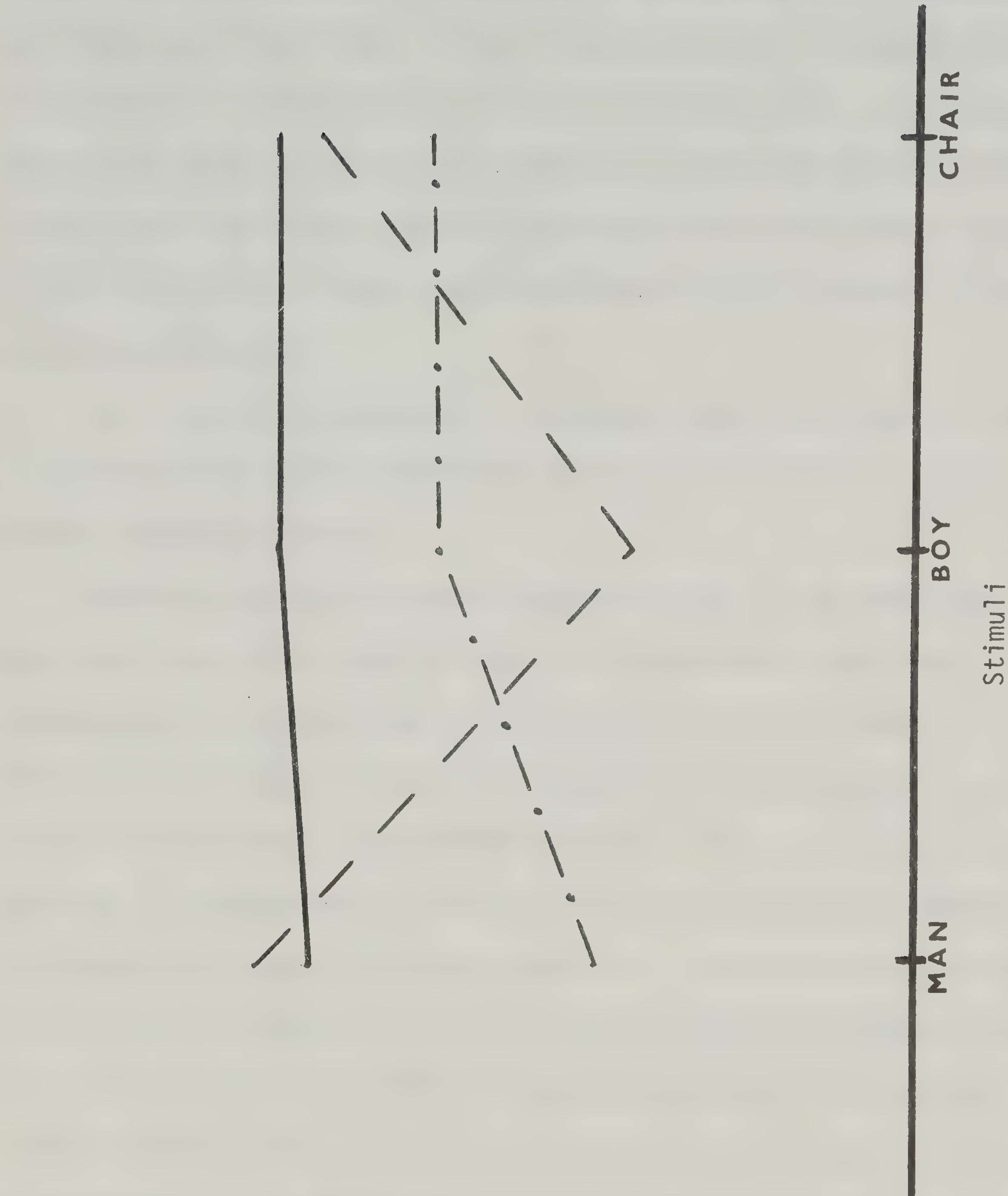
<u>Responses to MAN: Signal vs. nonsignal</u>. Specific comparisons for the signal MAN were carried out to determine the degree of "attention" to this signal when placed in different positions in a sequence. The last MAN signal in the nonsignal sequence MAN KEY MAN was compared to the imperative signal <u>MAN</u> in the signal sequence MAN BOY MAN. The last

Fig. 18. Mean % deceleration of heart rate (collapsed over blocks) to nonsignal sequence MAN BOY CHAIR for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


% Deceleration of Heart Rate (BPM)
4.0
3.0
2.0
1.0
MAN
BOY
CHAIR
Stimuli

signal MAN in the nonsignal sequence CAT BOY MAN was also compared to the imperative signal MAN. It was anticipated that the heart rate % deceleration component would differentiate the groups (i.e., greater heart rate deceleration for the imperative signal MAN than for either of the other two signals for the normal and instructed groups, with little difference in heart rate deceleration for the signals for the noninstructed group).

A 2 (groups) x 6 (blocks) x 2 (stimuli) ANOVA with the last two factors repeated was carried out utilizing % deceleration of heart rate as the dependent variable.

The only significant results obtained were for the comparisons of the last signal MAN in MAN KEY MAN to the imperative signal MAN. The instructed and normal groups both displayed a greater amount of deceleration of heart rate to the imperative signal MAN than to the signal MAN in the nonsignal sequence MAN KEY MAN. The noninstructed group, however, displayed more deceleration for the signal MAN as opposed to the imperative signal MAN (see Figure 19). The noninstructed group focused their "attention" as much or more on the signal MAN as they did for the imperative signal MAN. They appeared to be less selective in their attending than were the normal and instructed groups. This was found previously as well in the GSR results.

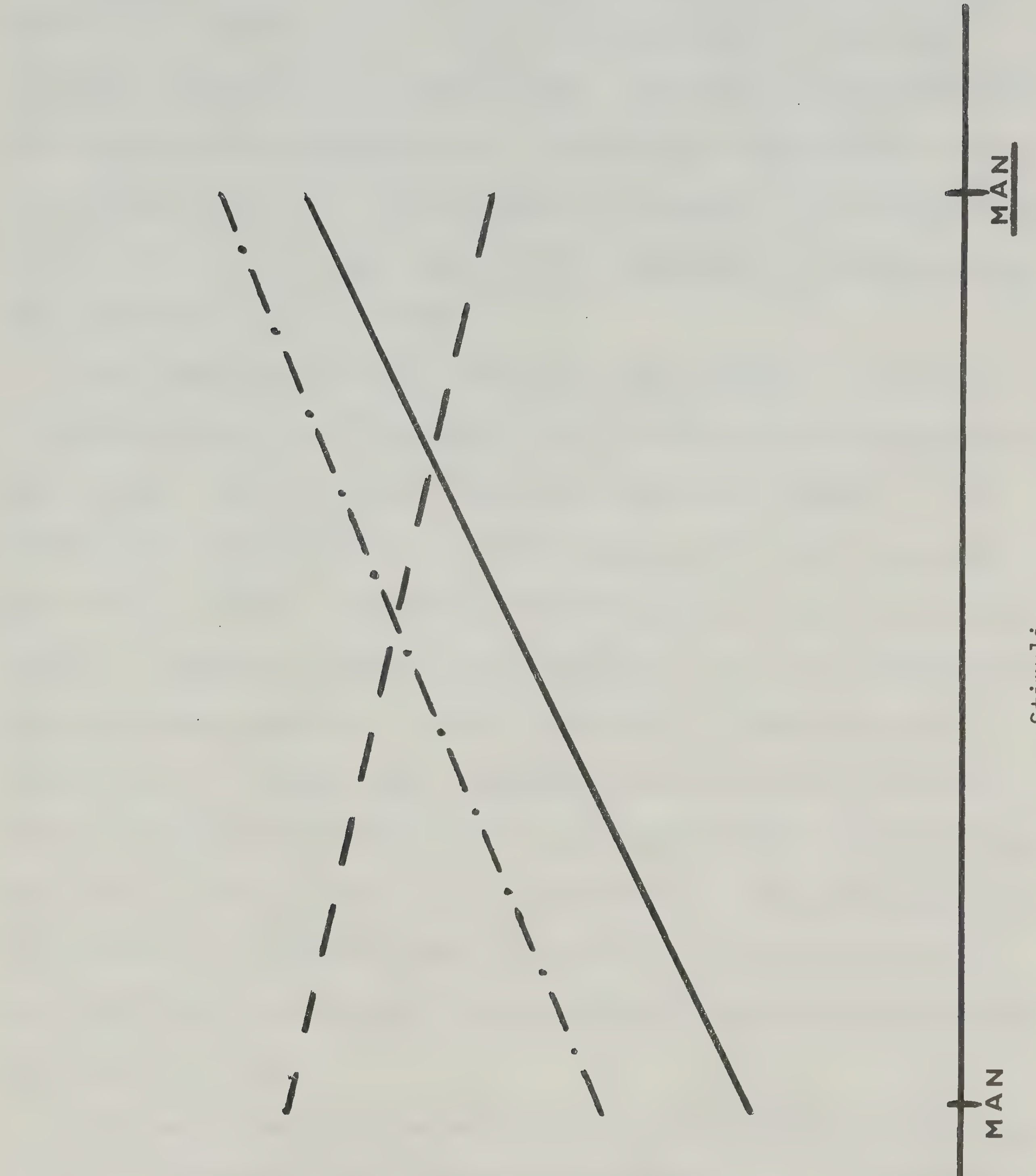
Discussion of heart rate data. Across blocks there was no evidence of habituation of the deceleration component of the heart rate response. This is contrary to the findings for the GSR measure, as the frequency of GSR did indicate quite consistently a decrement in responding over the blocks.

Fig. 19. Mean % deceleration of heart rate (collapsed over blocks) to imperative signal MAN and last MAN in nonsignal sequence MAN KEY MAN for all groups

Normal

Mentally retarded instructed

Mentally retarded noninstructed


% Deceleration of Heart Rate (BPM)
4.0
3.0
2.0
1.0
MAN
MAN
Stimuli

Hypothesis 3 predicted that the noninstructed group would display a faster rate of habituation of heart rate deceleration to the signal sequence as compared to the normal group. Hypothesis 3.1 predicted that the instructed group would display a slower rate of habituation of heart rate deceleration to the signal sequence as compared to the noninstructed group. There was no support obtained for habituation differences as heart rate habituation was not evident.

Some support was evident in the heart rate analyses for Hypothesis 3.2 which predicted that the normal group would display greater deceleration of heart rate to the most significant signals as compared to the noninstructed; and Hypothesis 3.3 which predicted that the instructed would display greater deceleration of heart rate to the most significant signals as compared to the noninstructed group. The normal and instructed groups were more selective in their "attending" as compared to the noninstructed. The normal and instructed groups did display more heart rate deceleration to the imperative signal <u>MAN</u> than they did for the last signal MAN in the nonsignal sequence MAN KEY MAN. The noninstructed, on the other hand, displayed as much or more heart rate deceleration to the signal MAN in the nonsignal sequence MAN KEY MAN as they did for the imperative signal MAN.

There was evidence in the heart rate data of differential responses to signals within the signal sequence MAN BOY <u>MAN</u> as well as within the nonsignal sequences CAT BOY MAN and MAN KEY MAN. The noninstructed group displayed more inconsistency in their heart rate responses to the signal stimuli than the normal or instructed groups. The heart rate responses of the normal and instructed groups were basically acceleratory

in nature, whereas the noninstructed displayed either no response (as was somewhat evident for BOY in the nonsignal sequence CAT BOY MAN) or deceleration (as was observed for BOY in the nonsignal sequence CAT BOY MAN and the last signal in the nonsignal sequence MAN KEY MAN).

Effect of instructions. The instructions to rehearse the signal sequence resulted in a somewhat more consistent heart rate response to the signals for the mentally retarded groups. The results here are not as clear as they were for the GSR data; however, there was an indication that the heart rate responses suggest a more "selective attending process" as a result of instructions. This was also evident in the GSR data discussed previously.

Heart rate change has also been noted to anticipate change in overt movement as when it goes up prior to actual speech in an interview situation (Murray, 1963) or up during the few seconds prior to a task during which the subject has been alerted that the task (signal) will be coming (Coles, 1974). The differences in responses to BOY may in fact be considered as a difference in "alerting" between the instructed and noninstructed groups. The signal then has more of an "alerting" effect on the instructed group as compared to the noninstructed. It was suggested earlier that the acceleration of heart rate might indicate covert rehearsal which has been suggested in some studies (Tursky, Swartz & Crider, 1970). The question of whether it is a function of cognitive processing ("rehearsal") or "alerting" cannot be conclusively answered with the data here. Perhaps they are interrelated as "alerting" could imply active cognitive activity. The GSR data did not clearly reveal an "alerting" aspect for the signal BOY, so it would seem more appropriate here to attribute the heart rate response to cognitive processing ("rehearsal").

CHAPTER VII

CONCLUSIONS

Normal and Retardate Differences

The results of the present study point to an impairment in the selective component of "attention" in the educable mentally retarded, as indicated in the orienting responses of the noninstructed to some of the nonsignals in the task. The vigilance performance of the non-instructed was inferior to both the normals and the instructed. The autonomic measures suggested that the performance differences were a function of lack of selection with respect to "attending" to the most significant stimuli. The noninstructed evidenced greater autonomic responsivity to some of the less significant stimuli in the task than the instructed. There was evidence of this in both the HR and GSR analyses.

There was no indication in this of general arousal level differences between normals and retardates. There was, however, indication of the mentally retarded responding to some of the less significant stimuli to a greater extent than the normals as evidenced particularly for the GSR to the first signal MAN in MAN KEY MAN. The mentally retarded here appeared to be more at the beck and call of some of the nonsignals than the normal or instructed (Denny, 1966). The data, however, was not consistent in this respect.

Effect of Instructions

The explicit instructions to rehearse the signal sequence and associate this with the press response clearly improved the vigilance performance of the mentally retarded. The instructions appeared to focus the attention of the retarded on the signal sequence and more specifically on the imperative signal MAN in this sequence. Also, the arousal properties of some of the other less significant signals were decreased for the instructed. This was most clear in the GSR analysis but was supported to some extent in the HR data as well.

In the present task it is clear that short-term memory is involved with respect to the signal and nonsignal sequences. For instance, one must remember that CAT was said at the beginning of the nonsignal sequence CAT BOY MAN. The instructions may have assisted this in terms of rehearsal and maintenance of a set with respect to the signal sequence. The HR data did indicate some covert and/or overt cognitive activity, particularly in response to the critical signal BOY in the normal and instructed groups. This was not displayed clearly by the noninstructed. It seems that retardates may thus be less "intelligent", not because they cannot rehearse, group or organize information, but rather they cannot spontaneously do this in terms of the most effective method or strategy.

On the basis of the results of this study and others (Belmont & Butterfield, 1971), it appears that training in strategies such as rehearsal can increase the level of retardates' performance to some extent. The question of generalization still needs to be explored fully. The effect of training retardates in strategies of coping with a task and

generalizing the strategy to other tasks requiring similar strategies is a fruitful area for further research.

GSR and HR habituation

There was no consistently clear evidence for differences of habituation of the orienting response for the three groups obtained in this study. This follows others who have failed to obtain differences in rate of habituation between retardates and normals (cf. Heal & Johnson, 1970).

There was, however, disparity in habituation of the GSR and HR components. GSR displayed consistent habituation to the stimuli for all three groups, whereas deceleration of HR did not. Habituation which is observed in one autonomic response system does not always appear in another. The inconsistencies relative to different autonomic measures of habituation have been noted by others (cf. Graham, 1973). It would seem that one must specify the system which is sensitive to habituation in a particular experimental paradigm.

In this experiment the stimuli were all in one modality and all were meaningful verbal stimuli. Heart rate may be most sensitive to the cognitive aspect when meaningful verbal stimuli are utilized and therefore should not habituate as easily as GSR which may not be as sensitive. HR is more sensitive to motor response. As this study involved motor responses in terms of key pressing and possible covert and/or overt verbalizations it is conceivable that this would give rise to no habituation. However, other studies in which no overt motor responses were required have obtained similar results. More complete

investigations into the nature of GSR and HR habituation, particularly involving verbal and nonverbal stimuli, might further our understanding of the possible relationships between autonomic responsivity and central processing.

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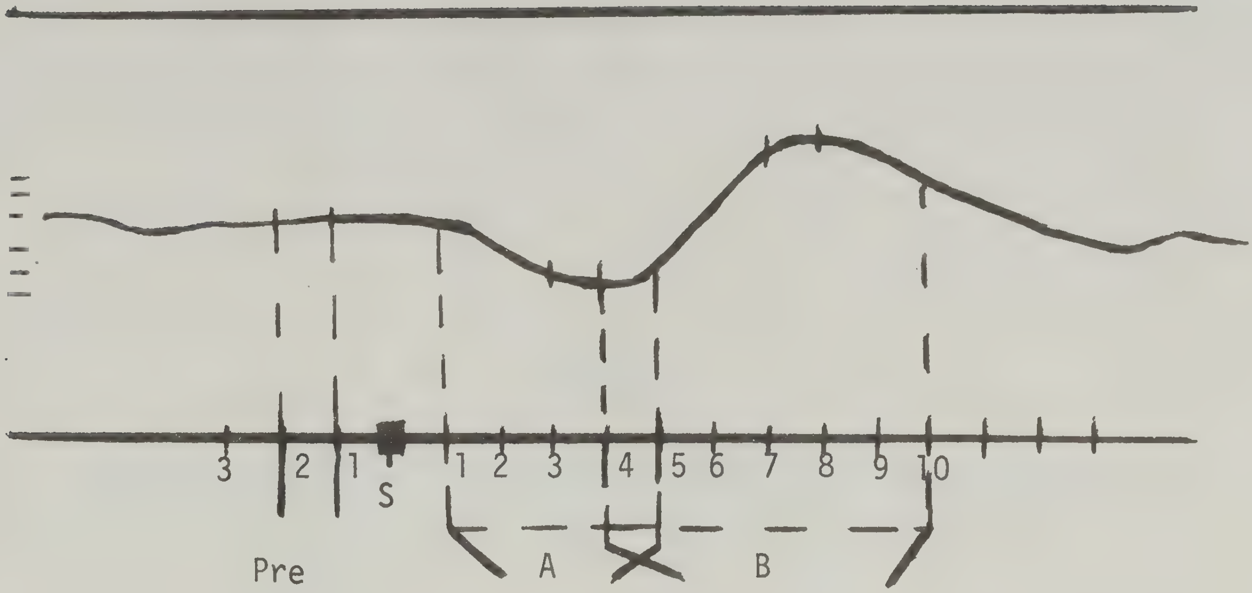
APPENDIX A

Examples of the Calculation
of % Deceleration and % Acceleration of Heart Rate



% Deceleration Calculation

The two-second prestimulus values obtained, e.g., 80 and 82 BPM were scored. The two lowest BPM in time period A above (5 seconds poststimulus obtained, e.g., 71 and 73). Mean BPM prestimulus is (80 + 82)/2 = 81 BPM. Mean of two lowest BPM in 5 seconds poststimulus is (71 + 73)/2 = 72 BPM. % deceleration = 100 x 81 - 72/81 = 11.11%.

% Acceleration Calculation

The mean prestimulus as in above % deceleration example was taken, e.g., 81 BPM. Mean of two highest BPM in 4-10 second poststimulus from time period B above, e.g., 91 and 93 BPM. Mean of two highest BPM post-stimulus was taken: (93 - 91)/2 = 92 BPM. % acceleration = 100 x (92 - 81/81) = 11.11%.

The percent deceleration to the stimulus was interpreted as an orienting response to the stimulus. Percent acceleration would be considered in terms of a cognitive response to the stimulus (Lacey, 1959).

APPENDIX B

ANOVA Tables:
GSR Log_e Prestimulus Conductance
and Prestimulus Heart Rate Analyses for Signal Sequence

Table B1

ANOVA for Normal vs. Noninstructed:
MAN BOY MAN signal sequence; prestimulus Log_e conductance

Source	df	MS	F	p
Between				
Groups	1	0.38	0.07	NS
Error	28	5.68		
Within				
Blocks	5	0.94	4.96	$\leq .01$
Blocks x groups	5	0.07	0.35	NS
Error	140	0.19		
Stimuli	2	0.00	2.53	NS
Stimuli x groups	2	0.00	2.29	NS
Error	56	0.00		
Blocks x stimuli	10	0.00	1.26	NS
Blocks x stimuli x groups	10	0.00	0.89	NS
Error	280	0.00		

Table B2

ANOVA for Instructed vs. Noninstructed:
MAN BOY MAN signal sequence; prestimulus Log_e conductance

Source	df	MS	F	p
Between				
Groups	1	0.04	0.01	NS
Error	28	7.12		
Within				
Blocks	5	0.99	3.94	≤.025
Blocks x groups	5	0.06	0.25	NS
Error	140	0.25		
Stimuli	2	0.00	0.83	NS
Stimuli x groups	2	0.00	0.44	NS
Error	56	0.00		
Blocks x stimuli	10	0.00	0.64	NS
Blocks x stimuli x groups	10	0.00	1.39	NS
Error	280	0.00		

Table B3

ANOVA for Normal vs. Noninstructed:
MAN BOY <u>MAN</u> signal sequence; prestimulus HR

Source	df	MS	F	p
Between				
Groups	1	1572.52	1.01	NS
Error	28	1553.64		
Within				
Blocks	5	31.19	0.66	NS
Blocks x groups	5	87.91	1.86	NS
Error	140	47.31		
Stimuli	2	29.18	1.04	NS
Stimuli x groups	2	39.89	1.43	NS
Error	56	27.95		
Blocks x stimuli	10	21.38	1.01	NS
Blocks x stimuli x groups	10	26.21	1.24	NS
Error	280	21.18		

Table B4

ANOVA for Instructed vs. Noninstructed:
MAN BOY MAN signal sequence; prestimulus HR

Source	df	MS	F	p
Between				
Groups	1	1128.11	0.78	NS
Error	28	1440.58		
Within				
Blocks	5	28.00	0.74	NS
Blocks x groups	5	61.42	1.62	NS
Error	140	37.97		
Stimuli	2	6.48	0.24	NS
Stimuli x groups	2	0.60	0.02	NS
Error	56	26.83		
Blocks x stimuli	10	52.54	2.80	$\leq .05$
Blocks x stimuli x groups	10	25.02	1.33	NS
Error	280	18.79		

APPENDIX C

ANOVA Tables:
GSR Analyses for Nonsignal Sequences

Table C1

ANOVA for Normal vs. Noninstructed:
CAT BOY MAN nonsignal sequence; GSR sec x sec conductance change

Source	df	MS	F	p
Between				
Groups	1	1.80	2.09	NS
Error	28	0.86		
Within				
Blocks	5	1.61	1.14	NS
Blocks x groups	5	1.53	1.09	NS
Error	140	1.41		
Stimuli	2	4.12	3.73	≤.05
Stimuli x groups	2	0.99	0.89	NS
Error	56	1.10		
Seconds	9	0.91	11.10	≤.001
Seconds x groups	9	0.07	0.83	NS
Error	252	0.08		
Blocks x stimuli	10	2.27	2.15	≤.05
Blocks x stimuli x groups	10	1.94	1.84	NS
Error	280	1.06		
Blocks x seconds	45	0.19	3.32	≤.01
Blocks x seconds x groups	45	0.08	1.32	NS
Error	1260	0.06		
Stimuli x seconds	18	0.11	1.95	≤.05
Stimuli x seconds x groups	18	0.08	1.42	NS
Error	504	0.06		
Blocks x stimuli x seconds	90	0.10	2.15	≤.01
Blocks x stimuli x seconds x groups	90	0.08	1.73	≤.01
Error	2520	0.04		

Table C2

ANOVA for Normal vs. Noninstructed:
CAT BOY MAN nonsignal sequence; frequency

Source	df	MS	F	p
Between				
Groups	1	1.90	2.01	NS
Error	28	0.94		
Within				
Blocks	5	2.46	10.25	≤.001
Blocks x groups	5	0.06	0.24	NS
Error	140	0.24		
Stimuli	2	0.39	1.91	NS
Stimuli x groups	2	0.03	0.15	NS
Error	56	0.20		
Blocks x stimuli	10	0.16	1.00	NS
Blocks x stimuli x groups	10	0.17	1.08	NS
Error	280	0.16		

Table C3

ANOVA for Normal vs. Noninstructed:
CAT BOY MAN nonsignal sequence; magnitude

Source	df	MS	F	p
Between				
Groups	1	0.04	0.21	NS
Error	28	0.20		
Within				
Blocks	5	0.41	4.37	≤.025
Blocks x groups	5	0.01	0.12	
Error	140	0.09		
Stimuli	2	0.14	2.32	NS
Stimuli x groups	2	0.02	0.26	NS
Error	56	0.06		
Blocks x stimuli	10	0.05	1.14	NS
Blocks x stimuli x groups	10	0.02	0.50	NS
Error	280	0.04		

Table C4

ANOVA for Instructed vs. Noninstructed:
CAT BOY MAN nonsignal sequence; GSR sec x sec conductance change

Source	df	MS	F	p
Between				
Groups	1	1.16	1.87	NS
Error	28	0.62		
Within				
Blocks	5	0.31	0.27	NS
Blocks x groups	5	2.43	2.09	NS
Error	140	1.16		
Stimuli	2	3.04	2.31	NS
Stimuli x groups	2	2.70	2.05	NS
Error	56	1.32		
Seconds	9	0.65	6.53	$\leq .01$
Seconds x groups	9	0.15	1.48	NS
Error	252	0.10		
Blocks x stimuli	10	1.51	1.26	NS
Blocks x stimuli x groups	10	3.50	2.92	$\leq .01$
Error	280	1.20		
Blocks x seconds	45	0.19	2.57	$\leq .01$
Blocks x seconds x groups	45	0.11	1.43	$\leq .05$
Error	1260	0.07		
Stimuli x seconds	18	0.10	1.41	NS
Stimuli x seconds x groups	18	0.12	1.76	$\leq .05$
Error	504	0.07		
Blocks x stimuli x seconds	90	0.09	1.87	$\leq .01$
Blocks x stimuli x seconds x groups	90	0.11	2.18	$\leq .01$
Error	2520	0.05		

Table C5

ANOVA for Instructed vs. Noninstructed:
CAT BOY MAN nonsignal sequence; frequency

Source	df	MS	F	p
Between				
Groups	1	4.09	4.23	≤.05
Error	28	0.97		
Within				
Blocks	5	2.29	11.31	≤.001
Blocks x groups	5	0.06	0.32	NS
Error	140	0.20		
Stimuli	2	0.14	0.77	NS
Stimuli x groups	2	0.32	1.73	NS
Error	56	0.18		
Blocks x stimuli	10	0.27	1.70	NS
Blocks x stimuli x groups	10	0.15	0.90	NS
Error	280	0.16		

Table C6

ANOVA for Instructed vs. Noninstructed:
CAT BOY MAN nonsignal sequence; magnitude

Source	df	MS	F	p
Between				
Groups	1	0.01	0.02	NS
Error	28	0.33		
Within				
Blocks	5	0.42	3.30	≤.025
Blocks x groups	5	0.05	0.42	NS
Error	140	0.13		
Stimuli	2	0.22	2.36	NS
Stimuli x groups	2	0.26	2.78	NS
Error	56	0.09		
Blocks x stimuli	10	0.05	0.65	NS
Blocks x stimuli x groups	10	0.04	0.53	NS
Error	280	0.07		

Table C7

ANOVA for Normal vs. Noninstructed:
MAN KEY MAN nonsignal sequence; GSR sec x sec conductance change

Source	df	MS	F	p
Between				
Groups	1	0.10	0.10	NS
Error	28	0.95		
Within				
Blocks	5	0.70	1.36	NS
Blocks x groups	5	0.66	1.29	NS
Error	140	0.51		
Stimuli	2	1.83	3.46	≤.05
Stimuli x groups	2	1.21	2.28	NS
Error	56	0.53		
Seconds	9	0.49	7.14	≤.001
Seconds x groups	9	0.05	0.72	NS
Error	252	0.07		
Blocks x stimuli	10	0.83	0.88	NS
Blocks x stimuli x groups	10	1.96	2.07	≤.01
Error	280	0.95		
Blocks x seconds	45	0.13	3.39	≤.01
Blocks x seconds x groups	45	0.04	1.21	NS
Error	1260	0.04		
Stimuli x seconds	18	0.05	1.92	≤.05
Stimuli x seconds x groups	18	0.04	1.57	NS
Error	504	0.03		
Blocks x stimuli x seconds	90	0.04	1.23	NS
Blocks x stimuli x seconds x groups	90	0.06	1.59	≤.05
Error	2520	0.04		

Table C8

ANOVA for Normal vs. Noninstructed:
MAN KEY MAN nonsignal sequence; frequency

Source	df	MS	F	p
Between				
Groups	1	0.74	0.98	NS
Error	28	0.76		
Within				
Blocks	5	1.83	9.58	≤.001
Blocks x groups	5	0.50	2.63	≤.025
Error	140	0.19		
Stimuli	2	1.74	9.56	≤.001
Stimuli x groups	2	0.34	1.84	NS
Error	56	0.18		
Blocks x stimuli	10	0.09	0.48	NS
Blocks x stimuli x groups	10	0.27	1.50	NS
Error	280	0.18		

Table C9

ANOVA for Normal vs. Noninstructed:
MAN KEY MAN nonsignal sequence; magnitude

Source	df	MS	F	p
Between				
Groups	1	0.19	0.64	NS
Error	28	0.30		
Within				
Blocks	5	0.27	6.68	≤.001
Blocks x groups	5	0.04	0.97	
Error	140	0.04		
Stimuli	2	0.20	5.17	≤.01
Stimuli x groups	2	0.01	0.29	NS
Error	56	0.04		
Blocks x stimuli	10	0.05	0.92	NS
Blocks x stimuli x groups	10	0.05	0.97	NS
Error	280	0.05		

Table C10

ANOVA for Instructed vs. Noninstructed:
MAN KEY MAN nonsignal sequence; GSR sec x sec conductance change

Source	df	MS	F	p
Between				
Groups	1	2.31	1.87	NS
Error	28	1.24		
Within				
Blocks	5	0.74	0.71	NS
Blocks x groups	5	1.23	1.17	NS
Error	140	1.05		
Stimuli	2	0.18	0.36	NS
Stimuli x groups	2	3.64	7.34	≤.001
Error	56	0.50		
Seconds	9	0.42	4.92	≤.001
Seconds x groups	9	0.09	1.08	NS
Error	252	0.09		
Blocks x stimuli	10	2.05	1.60	NS
Blocks x stimuli x groups	10	1.47	1.15	NS
Error	280	1.28		
Blocks x seconds	45	0.09	1.87	NS
Blocks x seconds x groups	45	0.08	1.62	NS
Error	1260	0.05		
Stimuli x seconds	18	0.11	3.34	≤.001
Stimuli x seconds x groups	18	0.06	1.90	≤.025
Error	504	0.03		
Blocks x stimuli x seconds	90	0.08	1.43	NS
Blocks x stimuli x seconds x groups	90	0.06	1.00	NS
Error	2520	0.06		

Table C11

ANOVA for Instructed vs. Noninstructed:
MAN KEY MAN nonsignal sequence; frequency

Source	df	MS	F	p
Between				
Groups	1	1.07	1.13	NS
Error	28	0.94		
Within				
Blocks	5	1.26	7.35	≤.001
Blocks x groups	5	0.20	1.17	
Error	140	0.17		
Stimuli	2	1.10	8.39	≤.001
Stimuli x groups	2	0.69	5.27	≤.01
Error	56	0.13		
Blocks x stimuli	10	0.27	1.38	NS
Blocks x stimuli x groups	10	0.08	0.42	NS
Error	280	0.19		

Table C12

ANOVA for Normal vs. Noninstructed:
MAN BOY CHAIR nonsignal sequence; GSR sec x sec conductance change

Source	df	MS	F	p
Between				
Groups	1	2.50	0.92	NS
Error	28	2.70		
Within				
Blocks	5	2.42	1.07	NS
Blocks x groups	5	5.50	2.44	≤.05
Error	140	2.26		
Stimuli	2	0.46	0.15	NS
Stimuli x groups	2	4.28	1.34	NS
Error	56	3.19		
Seconds	9	0.59	5.95	≤.01
Seconds x groups	9	0.02	0.22	NS
Error	252	0.10		
Blocks x stimuli	10	3.00	1.21	NS
Blocks x stimuli x groups	10	3.13	1.26	NS
Error	280	2.48		
Blocks x seconds	45	0.31	3.37	≤.01
Blocks x seconds x groups	45	0.26	2.81	≤.01
Error	1260	0.09		
Stimuli x seconds	18	0.05	0.64	NS
Stimuli x seconds x groups	18	0.17	2.16	≤.01
Error	504	0.08		
Blocks x stimuli x seconds	90	0.10	1.76	≤.01
Blocks x stimuli x seconds x groups	90	0.13	2.18	≤.001
Error	2520	0.06		

Table C13

ANOVA for Instructed vs. Noninstructed:
MAN BOY CHAIR nonsignal sequence; GSR sec x sec conductance change

Source	df	MS	F	p
Between				
Groups	1	0.24	0.11	NS
Error	28	2.30		
Within				
Blocks	5	1.65	0.93	NS
Blocks x groups	5	6.69	3.78	≤.01
Error	140	1.77		
Stimuli	2	2.65	1.17	NS
Stimuli x groups	2	0.26	0.11	NS
Error	56	2.28		
Seconds	9	0.53	4.64	≤.01
Seconds x groups	9	0.04	0.33	NS
Error	252	0.11		
Blocks x stimuli	10	1.81	0.97	NS
Blocks x stimuli x groups	10	3.81	2.05	NS
Error	280	1.86		
Blocks x seconds	45	0.20	2.17	≤.01
Blocks x seconds x groups	45	0.37	3.95	≤.001
Error	1260	0.09		
Stimuli x seconds	18	0.11	1.42	NS
Stimuli x seconds x groups	18	0.10	1.22	NS
Error	504	0.08		
Blocks x stimuli x seconds	90	0.11	1.60	NS
Blocks x stimuli x seconds x groups	90	0.15	2.24	≤.01
Error	2520	0.07		

APPENDIX D

ANOVA Tables:
GSR Analysis for Signal MAN
vs. Last MAN in MAN KEY MAN Nonsignal Sequence

Table D1

ANOVA for Normal vs. Noninstructed:
MAN vs. Last MAN in MAN KEY MAN; magnitude

Source	df	MS	F	p
Between				
Groups	1	0.25	0.94	NS
Error	28	0.26		
Within				
Blocks	5	0.19	2.79	≤.05
Blocks x groups	5	0.01	0.19	
Error	140	0.07		
Stimuli	1	2.19	18.60	≤.001
Stimuli x groups	1	0.86	7.27	≤.01
Error	28	0.12		
Blocks x stimuli	5	0.07	1.62	NS
Blocks x stimuli x groups	5	0.08	1.78	NS
Error	140	0.05		

APPENDIX E

ANOVA Tables:
Heart Rate Analysis for Nonsignal Sequences

Table E1

ANOVA for Normal vs. Noninstructed:
MAN BOY CHAIR nonsignal sequence; HR sec x sec and BPM change

Source	df	MS	F	p
Between				
Groups	1	186.67	0.56	NS
Error	28	330.88		
Within				
Blocks	5	136.05	0.83	NS
Blocks x groups	5	391.73	2.40	≤.05
Error	140	163.14		
Stimuli	2	249.19	1.40	NS
Stimuli x groups	2	137.81	0.77	NS
Error	56	178.68		
Seconds	9	94.83	3.77	≤.01
Seconds x groups	9	10.93	0.43	NS
Error	252	25.17		
Blocks x stimuli	10	281.02	1.26	NS
Blocks x stimuli x groups	10	143.71	0.64	NS
Error	280	222.98		
Blocks x seconds	45	17.54	1.41	NS
Blocks x seconds x groups	45	25.83	2.08	≤.01
Error	1260	12.41		
Stimuli x seconds	18	57.61	4.17	≤.001
Stimuli x seconds x groups	18	8.29	0.60	NS
Error	504	13.82		
Blocks x stimuli x seconds	90	10.41	0.89	NS
Blocks x stimuli x seconds x groups	90	17.65	1.51	≤.01
Error	2520	11.67		

Table E2

ANOVA for Instructed vs. Noninstructed:
MAN BOY CHAIR nonsignal sequence; HR sec x sec and BPM change

Source	df	MS	F	p
Between				
Groups	1	142.76	0.64	NS
Error	28	224.07		
Within				
Blocks	5	268.65	1.60	NS
Blocks x groups	5	111.69	0.66	NS
Error	140	168.15		
Stimuli	2	154.75	1.08	NS
Stimuli x groups	2	32.48	0.23	NS
Error	56	143.55		
Seconds	9	128.71	6.33	$\leq .001$
Seconds x groups	9	4.73	0.23	NS
Error	252	20.33		
Blocks x stimuli	10	266.96	1.61	NS
Blocks x stimuli x groups	10	175.31	1.06	NS
Error	280	165.96		
Blocks x seconds	45	21.49	2.00	$\leq .01$
Blocks x seconds x groups	45	15.67	1.46	NS
Error	1260	10.72		
Stimuli x seconds	18	26.55	1.87	$\leq .05$
Stimuli x seconds x groups	18	29.64	2.09	$\leq .01$
Error	504	14.20		
Blocks x stimuli x seconds	90	20.78	2.17	$\leq .01$
Blocks x stimuli x seconds x groups	90	8.27	0.86	NS
Error	2520	9.59		

Table E3

ANOVA for Instructed vs. Noninstructed:
MAN BOY CHAIR nonsignal sequence; HR % deceleration

Source	df	MS	F	p
Between				
Groups	1	38.67	0.96	NS
Error	28	40.38		
Within				
Blocks	5	26.41	1.06	NS
Blocks x groups	5	11.96	0.48	NS
Error	140	24.81		
Stimuli	2	44.43	1.77	NS
Stimuli x groups	2	99.57	3.96	$\leq .05$
Error	56	25.16		
Blocks x stimuli	10	39.97	1.38	NS
Blocks x stimuli x groups	10	49.43	1.70	NS
Error	280	29.01		

Table E4

ANOVA for Normal vs. Noninstructed:
CAT BOY MAN nonsignal sequence; HR sec x sec and BPM change

Source	df	MS	F	p
Between				
Groups	1	100.59	0.47	NS
Error	28	214.65		
Within				
Blocks	5	19.67	0.09	NS
Blocks x groups	5	148.20	0.71	NS
Error	140	208.39		
Stimuli	2	252.75	0.94	NS
Stimuli x groups	2	561.45	2.10	NS
Error	56	267.98		
Seconds	9	46.53	3.94	≤.01
Seconds x groups	9	20.26	1.71	NS
Error	252	11.82		
Blocks x stimuli	10	163.98	0.59	NS
Blocks x stimuli x groups	10	193.04	0.69	NS
Error	280	278.24		
Blocks x seconds	45	25.70	2.00	≤.01
Blocks x seconds x groups	45	14.26	1.11	NS
Error	1260	12.87		
Stimuli x seconds	18	6.75	0.52	NS
Stimuli x seconds x groups	18	17.66	1.35	NS
Error	504	13.05		
Blocks x stimuli x seconds	90	14.92	1.18	NS
Blocks x stimuli x seconds x groups	90	11.21	0.89	NS
Error	2520	12.60		

Table E5

ANOVA for Instructed vs. Noninstructed:
CAT BOY MAN nonsignal sequence; HR sec x sec and BPM change

Source	df	MS	F	p
Between				
Groups	1	109.80	0.67	NS
Error	28	164.47		
Within				
Blocks	5	175.47	0.76	NS
Blocks x groups	5	60.73	0.26	NS
Error	140	232.47		
Stimuli	2	321.36	1.28	NS
Stimuli x groups	2	517.67	2.07	NS
Error	56	250.36		
Seconds	9	75.31	6.35	$\leq .001$
Seconds x groups	9	30.15	2.54	$\leq .01$
Error	252	11.86		
Blocks x stimuli	10	188.31	0.86	NS
Blocks x stimuli x groups	10	306.79	1.40	NS
Error	280	219.86		
Blocks x seconds	45	13.44	1.16	NS
Blocks x seconds x groups	45	19.02	1.65	NS
Error	1260	11.55		
Stimuli x seconds	18	6.42	0.53	NS
Stimuli x seconds x groups	18	21.78	1.78	$\leq .05$
Error	504	12.22		
Blocks x stimuli x seconds	90	17.00	1.73	$\leq .05$
Blocks x stimuli x seconds x groups	90	11.89	1.21	NS
Error	2520	9.84		

Table E6

ANOVA for Normal vs. Noninstructed:
MAN KEY MAN nonsignal sequence; HR sec x sec and BPM change

Source	df	MS	F	p
Between				
Groups	1	262.24	1.00	NS
Error	28	261.39		
Within				
Blocks	5	131.48	0.67	NS
Blocks x groups	5	454.36	2.33	≤.05
Error	140	195.00		
Stimuli	2	457.94	2.39	NS
Stimuli x groups	2	83.06	0.43	NS
Error	56	191.32		
Seconds	9	130.14	7.42	≤.001
Seconds x groups	9	15.58	0.89	NS
Error	252	17.54		
Blocks x stimuli	10	188.37	0.86	NS
Blocks x stimuli x groups	10	401.63	1.83	≤.05
Error	280	219.23		
Blocks x seconds	45	20.88	1.94	NS
Blocks x seconds x groups	45	12.98	1.21	NS
Error	1260	10.76		
Stimuli x seconds	18	8.71	0.54	NS
Stimuli x seconds x groups	18	47.47	2.95	≤.01
Error	504	16.11		
Blocks x stimuli x seconds	90	11.53	0.89	NS
Blocks x stimuli x seconds x groups	90	12.91	1.00	NS
Error	2520	12.91		

Table E7

ANOVA for Instructed vs. Noninstructed:
MAN KEY MAN nonsignal sequence; HR sec x sec and BPM change

Source	df	MS	F	p
Between				
Groups	1	21.03	0.09	NS
Error	28	244.16		
Within				
Blocks	5	315.35	1.44	NS
Blocks x groups	5	210.63	0.96	NS
Error	140	219.19		
Stimuli	2	414.07	1.97	NS
Stimuli x groups	2	270.31	1.29	NS
Error	56	210.35		
Seconds	9	147.27	10.52	≤.001
Seconds x groups	9	7.62	0.54	NS
Error	252	14.01		
Blocks x stimuli	10	241.06	0.90	NS
Blocks x stimuli x groups	10	208.22	0.78	NS
Error	280	266.76		
Blocks x seconds	45	8.96	0.88	NS
Blocks x seconds x groups	45	11.21	1.10	NS
Error	1260	10.21		
Stimuli x seconds	18	20.84	1.55	NS
Stimuli x seconds x groups	18	28.36	2.11	≤.001
Error	504	13.47		
Blocks x stimuli x seconds	90	11.25	1.08	NS
Blocks x stimuli x seconds x groups	90	13.92	1.34	≤.05
Error	2520	10.43		

Table E8

ANOVA for Normal vs. Noninstructed:
MAN KEY MAN nonsignal sequence; HR % acceleration

Source	df	MS	F	p
Between				
Groups	1	241.95	4.09	≤.05
Error	28	59.23		
Within				
Blocks	5	142.29	3.09	≤.05
Blocks x groups	5	79.16	1.72	NS
Error	140	46.03		
Stimuli	2	4.59	0.11	NS
Stimuli x groups	2	44.57	1.09	NS
Error	56	41.08		
Blocks x stimuli	10	39.56	0.91	NS
Blocks x stimuli x groups	10	71.34	1.64	NS
Error	280	43.51		

APPENDIX F

ANOVA Tables:
Heart Rate Analyses for MAN
vs. Last MAN in Nonsignal Sequence MAN KEY MAN

Table F1

ANOVA for Normal vs. Noninstructed:
MAN vs. last MAN in MAN KEY MAN; HR % deceleration

Source	df	MS	F	p
Between				
Groups	1	36.77	1.37	NS
Error	28	26.87		
Within				
Blocks	5	44.05	1.22	NS
Blocks x groups	5	51.68	1.43	NS
Error	140	36.14		
Stimuli	1	17.10	0.50	NS
Stimuli x groups	1	291.83	8.47	≤.001
Error	28	34.45		
Blocks x stimuli	5	25.83	0.74	NS
Blocks x stimuli x groups	5	24.06	0.69	NS
Error	140	35.11		

Table F2

ANOVA for Instructed vs. Noninstructed:
MAN vs. last MAN in MAN KEY MAN; HR % deceleration

Source	df	MS	F	p
Between				
Groups	1	28.12	0.76	NS
Error	28	36.99		
Within				
Blocks	5	50.21	1.07	NS
Blocks x groups	5	40.67	0.86	NS
Error	140	47.09		
Stimuli	1	65.91	0.99	NS
Stimuli x groups	1	443.78	6.64	$\leq .01$
Error	28	66.89		
Blocks x stimuli	5	59.79	1.24	NS
Blocks x stimuli x groups	5	16.81	0.35	NS
Error	140	48.06		

APPENDIX G

Vigilance Task and Procedures

The following instructions were given to both the normal and noninstructed groups; instructions were prerecorded on tape. The tape was turned on after having settled the subject in the chair with electrodes attached.

"You are going to hear a series of words. Whenever you hear the sequence MAN BOY MAN you are to press the key when you hear the last word MAN. Only press the key when you hear this sequence, MAN BOY MAN. Do not press for any other. Okay, now let's try it." [The following stimuli were then presented: KEY HEN MAN BOY MAN.] If the subject pressed correctly, the experimenter would say, "Good, that's right. Now let's try another." If the subject pressed incorrectly, the experimenter would say, "No", and then repeat the instructions. When three consecutive correct responses were made, the experimenter would say, "Okay, now I'm going to let you go on your own."

For the instructed group, the following instructions were given. "You are going to hear a series of words. Whenever you hear the sequence MAN BOY MAN you are to press the key when you hear the last word MAN. Only press the key when you hear this sequence, MAN BOY MAN. Do not press for any other. Say out loud: MAN BOY MAN Press! MAN BOY MAN Press! Let me hear you. [Pause] Okay, keep saying this over and over all the time you are here: MAN BOY MAN Press! Do not stop. Okay, now let's try it." [The following stimuli were then presented: KEY HEN MAN BOY MAN.] If the subject was right, the experimenter said: "Good, that's right. Now let's try another." If the subject pressed incorrectly, the experimenter would say, "No", and repeat the

instructions. When three consecutive correct responses were made, the experimenter would say, "Okay, now I am going to let you go on your own. [Pause] A series of words (see Figure G1) was spoken from the pre-recorded tape. The same tape was used for all subjects. Interstimulus intervals between words were 16 seconds.

List of Stimulus Words in Order as Pretaped

cat	man	man	man
boy	hen	cow	hen
man	key	cat	man
hen	man	man	boy
man	boy	boy	man
key	man	chair	cow
man	hen	hen	cat
cow	man	man	boy
key	boy	boy	man
man	chair	man	hen
boy	cow	cat	man
man	man	key	boy
key	boy	man	chair
hen	man	boy	cat
man	cow	man	key
boy	hen	cow	man
chair	man	man	key
hen	boy	key	man
man	man	man	cow
boy	key	cat	man
man	man	boy	boy
cow	boy	man	man
hen	chair	hen	key
man	cat	key	cat
key	cow	man	boy
man	cat	boy	man
cow	boy	man	cow
key	man	cow	man
cat	hen	man	boy
boy	man	boy	man
	boy	chair	
	man	key	
	chair	cow	
	man	man	
	key	key	

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